THE ENGINEER

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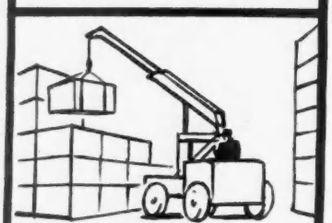
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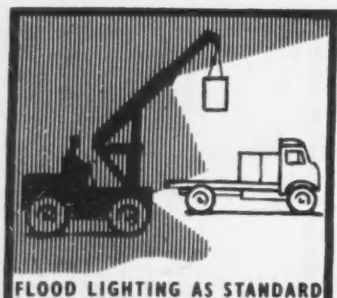
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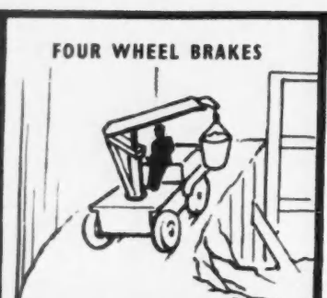
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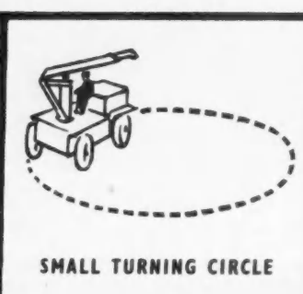
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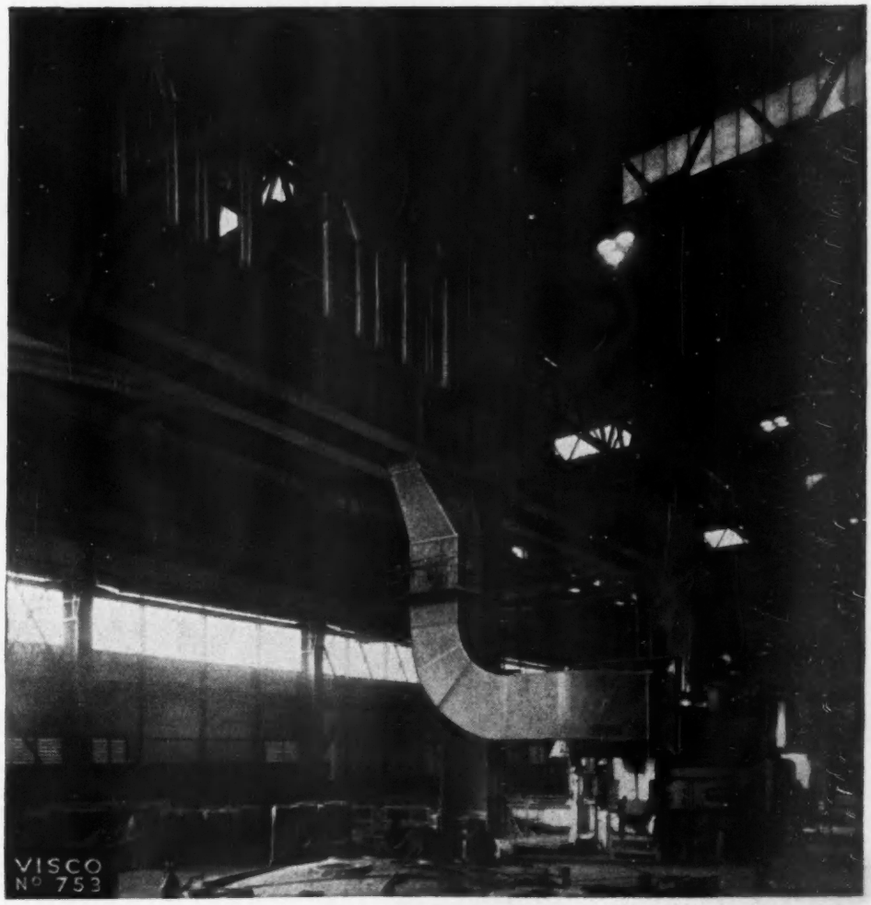

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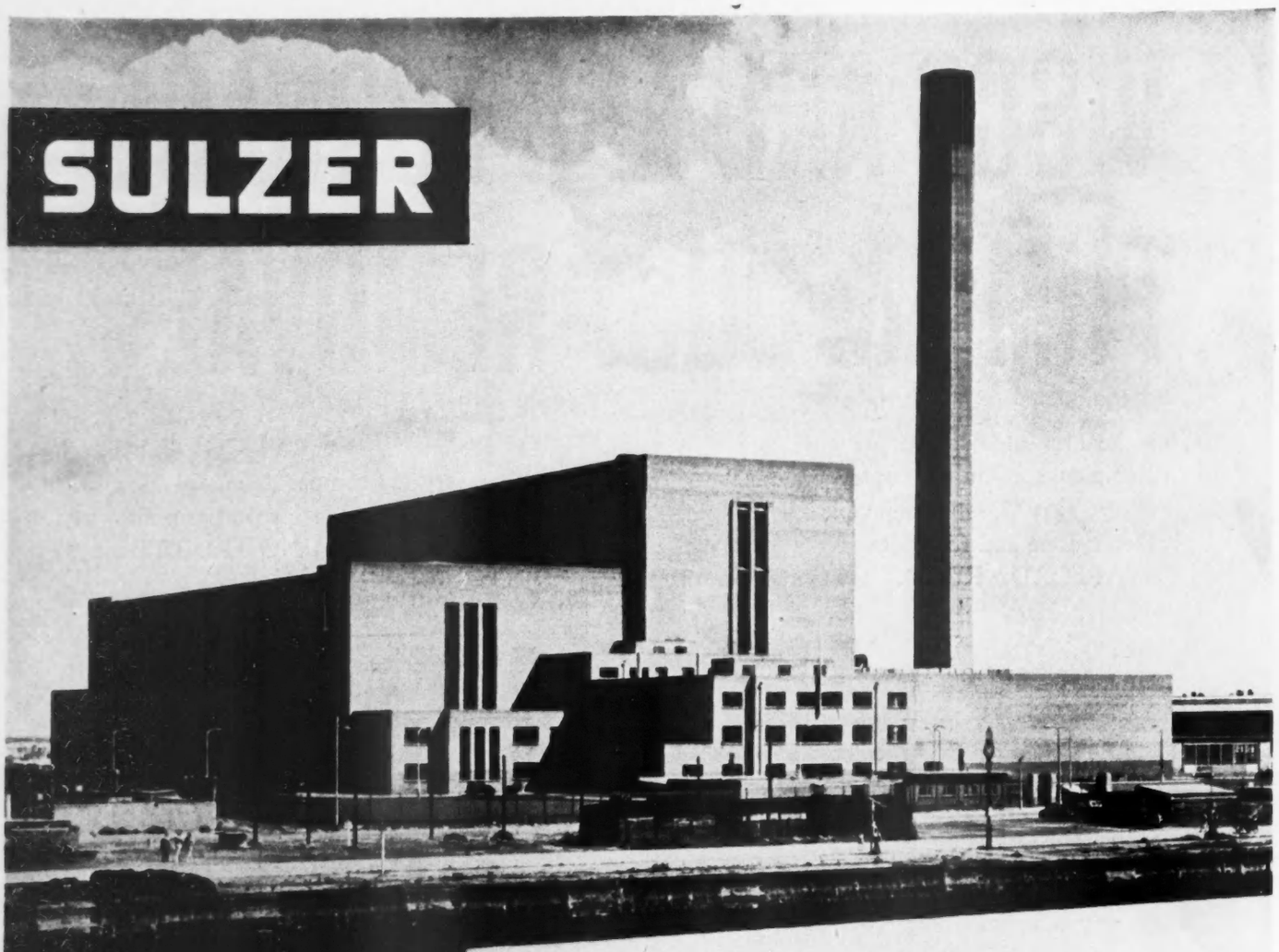

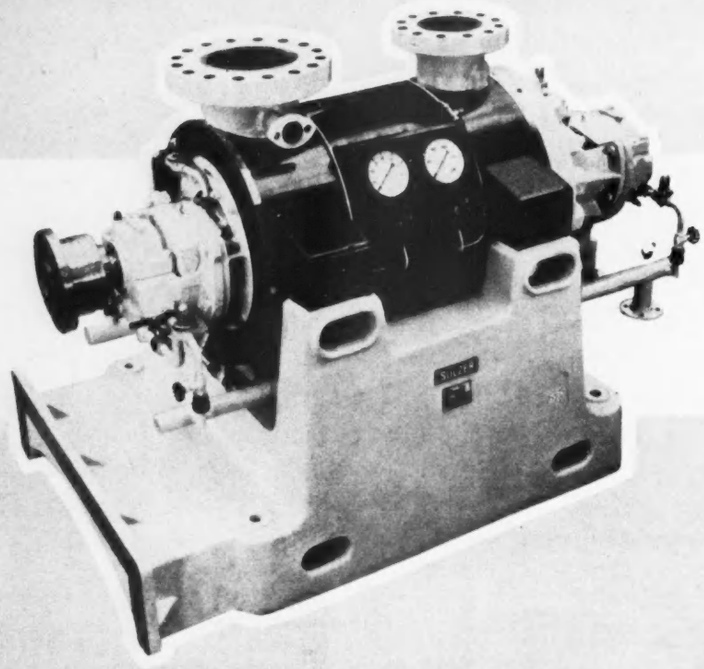

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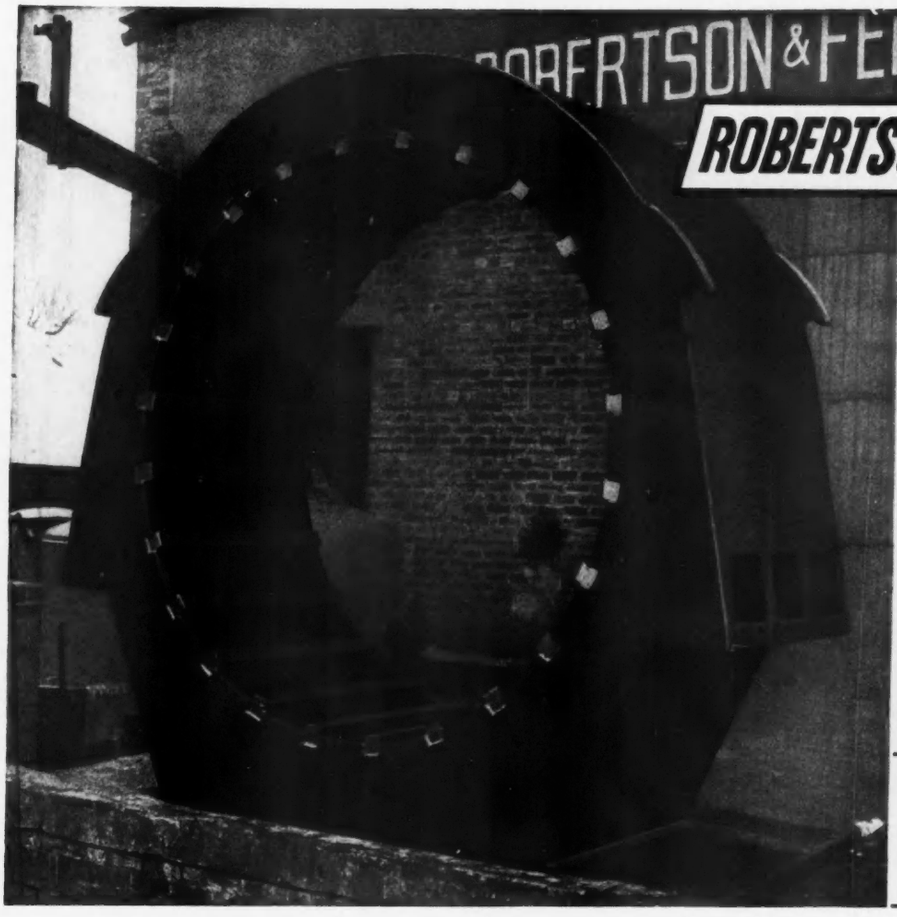

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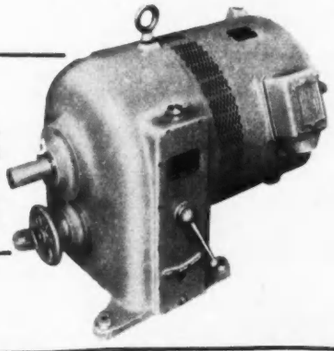

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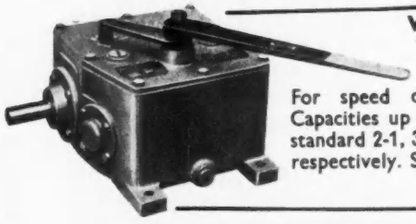

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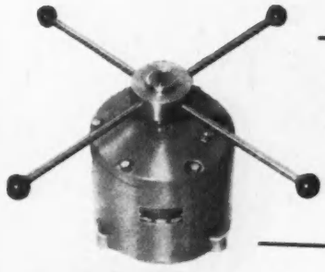

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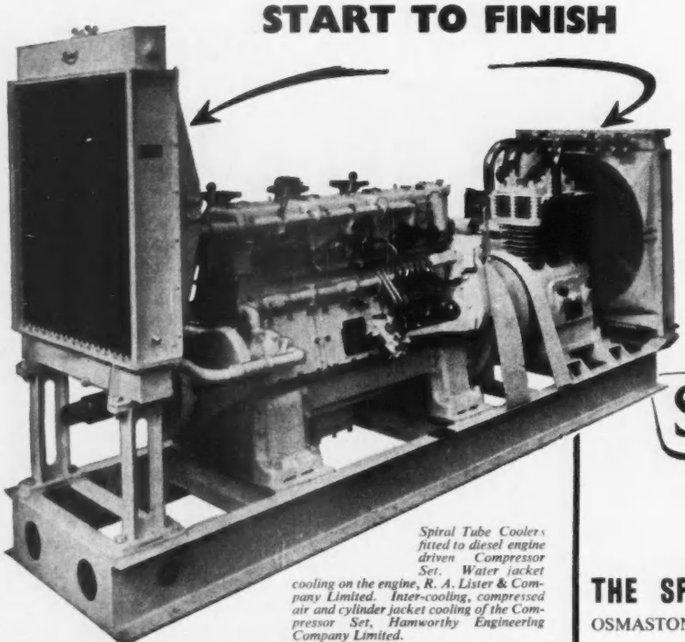

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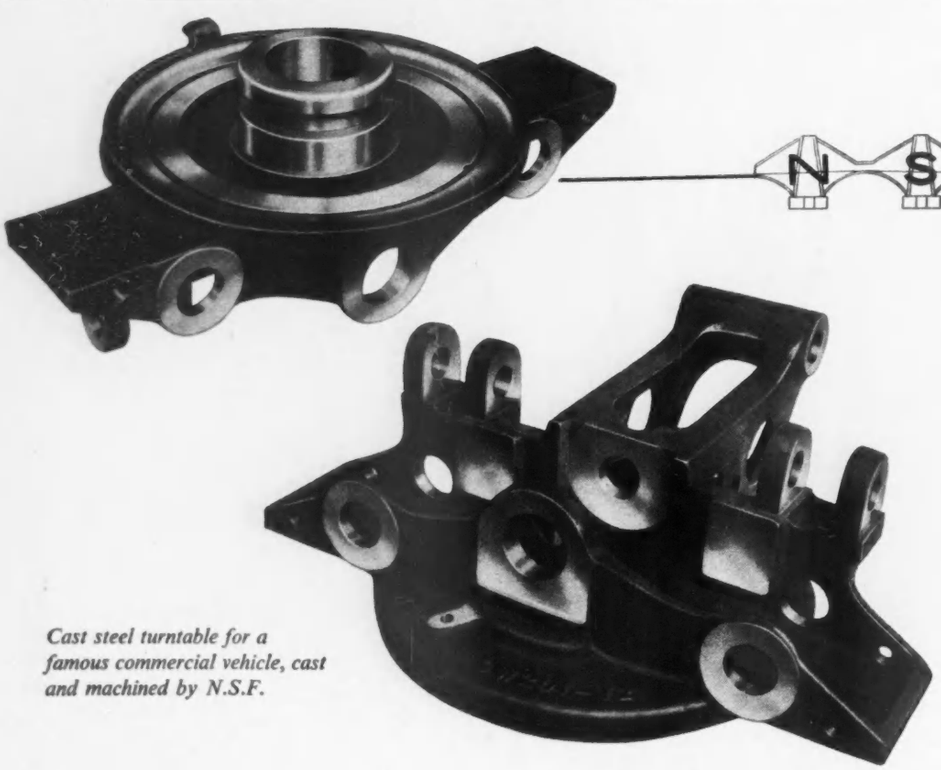

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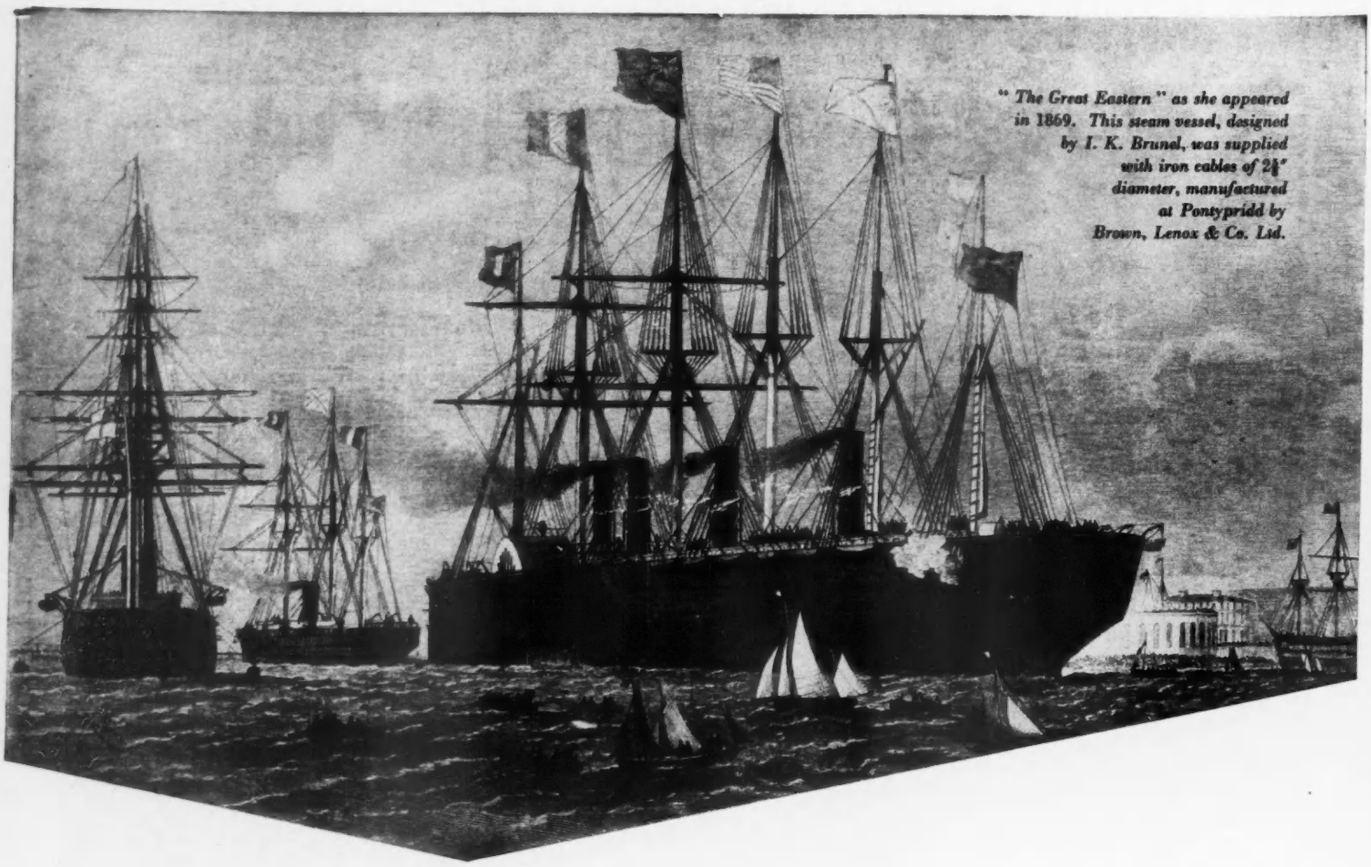

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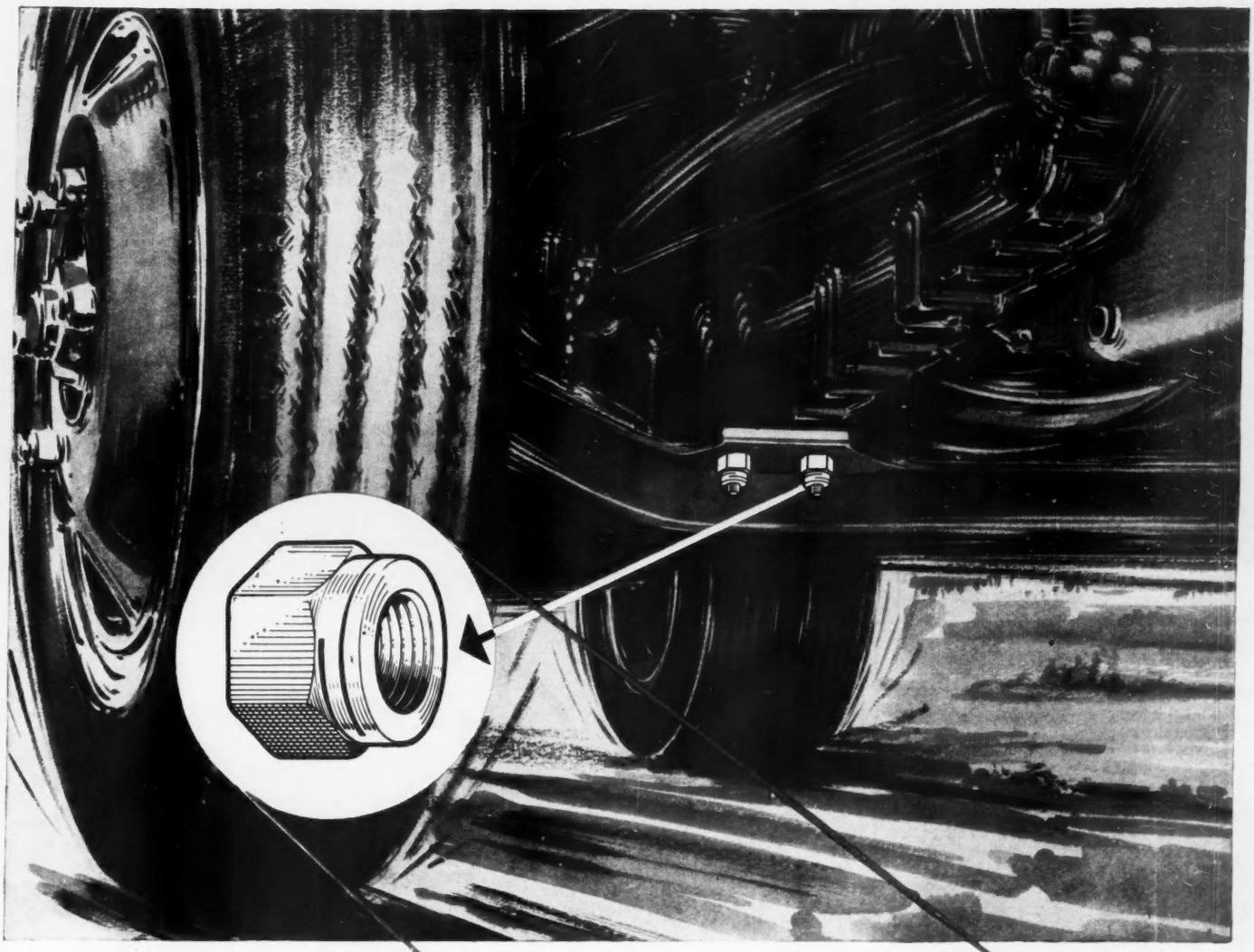

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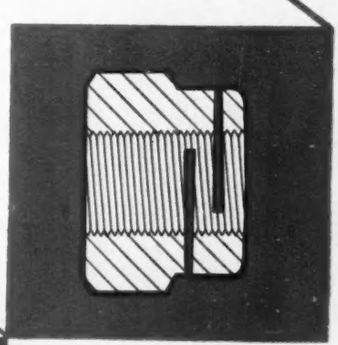

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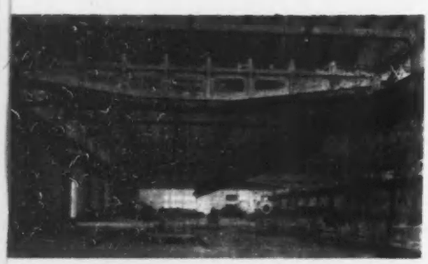

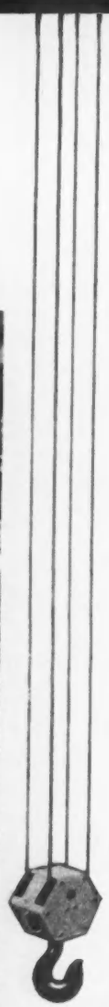

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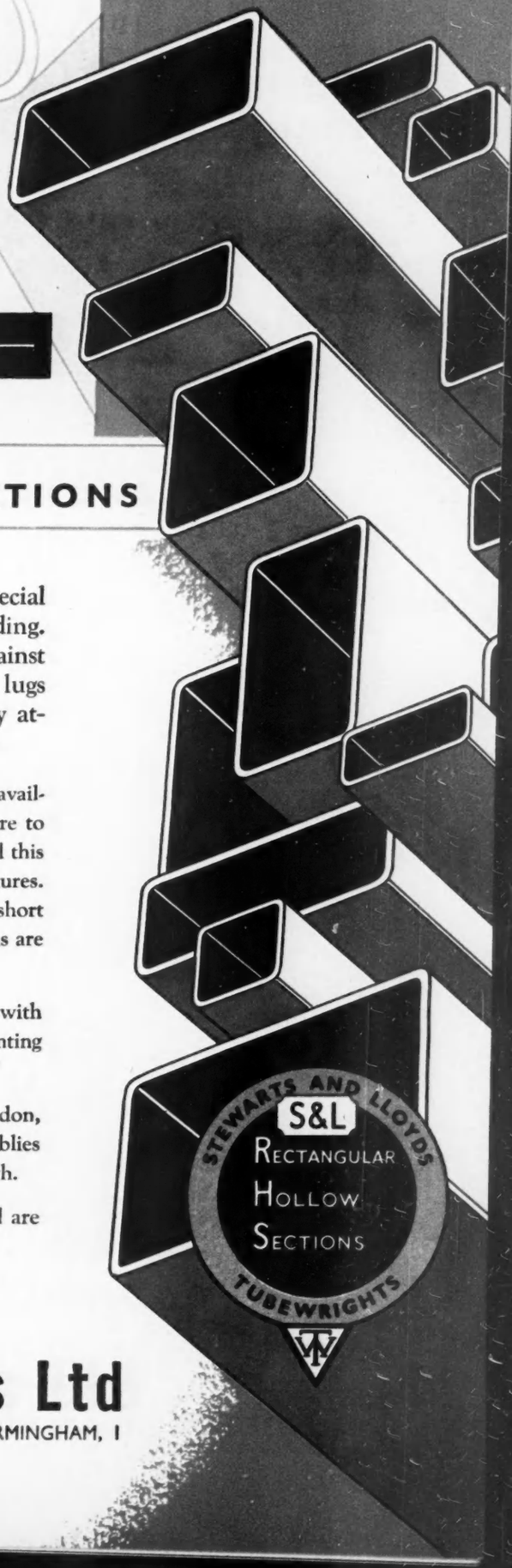

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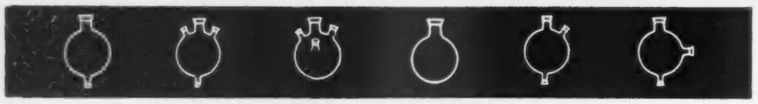

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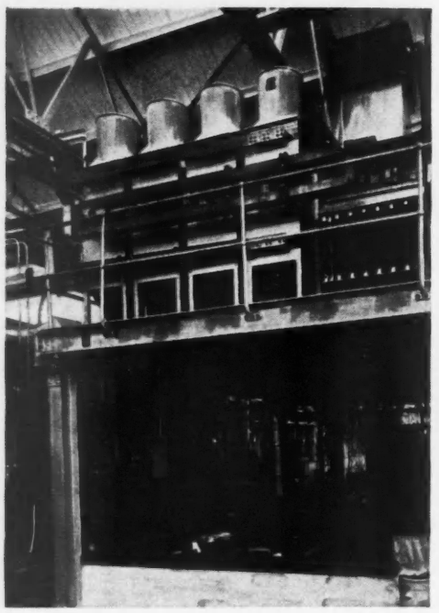
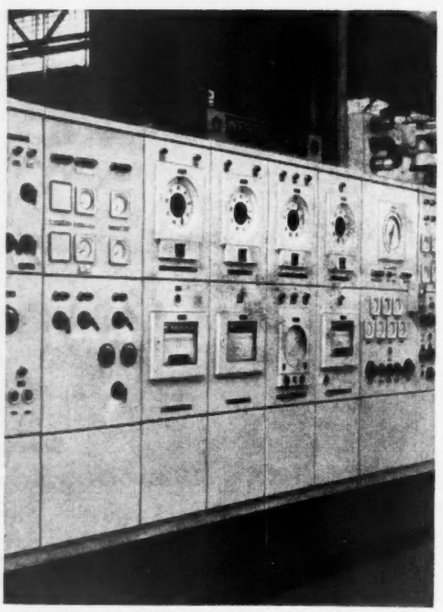


1936 *Part of a 50 000 ampere copper-oxide rectifier installation at Joseph Lucas Ltd.*



1958 *Part of the control panel of one of the electro-tinning lines of The Steel Company of Wales Ltd., Velindre, employing 450 000 amperes of water-cooled Westalite rectifiers.*

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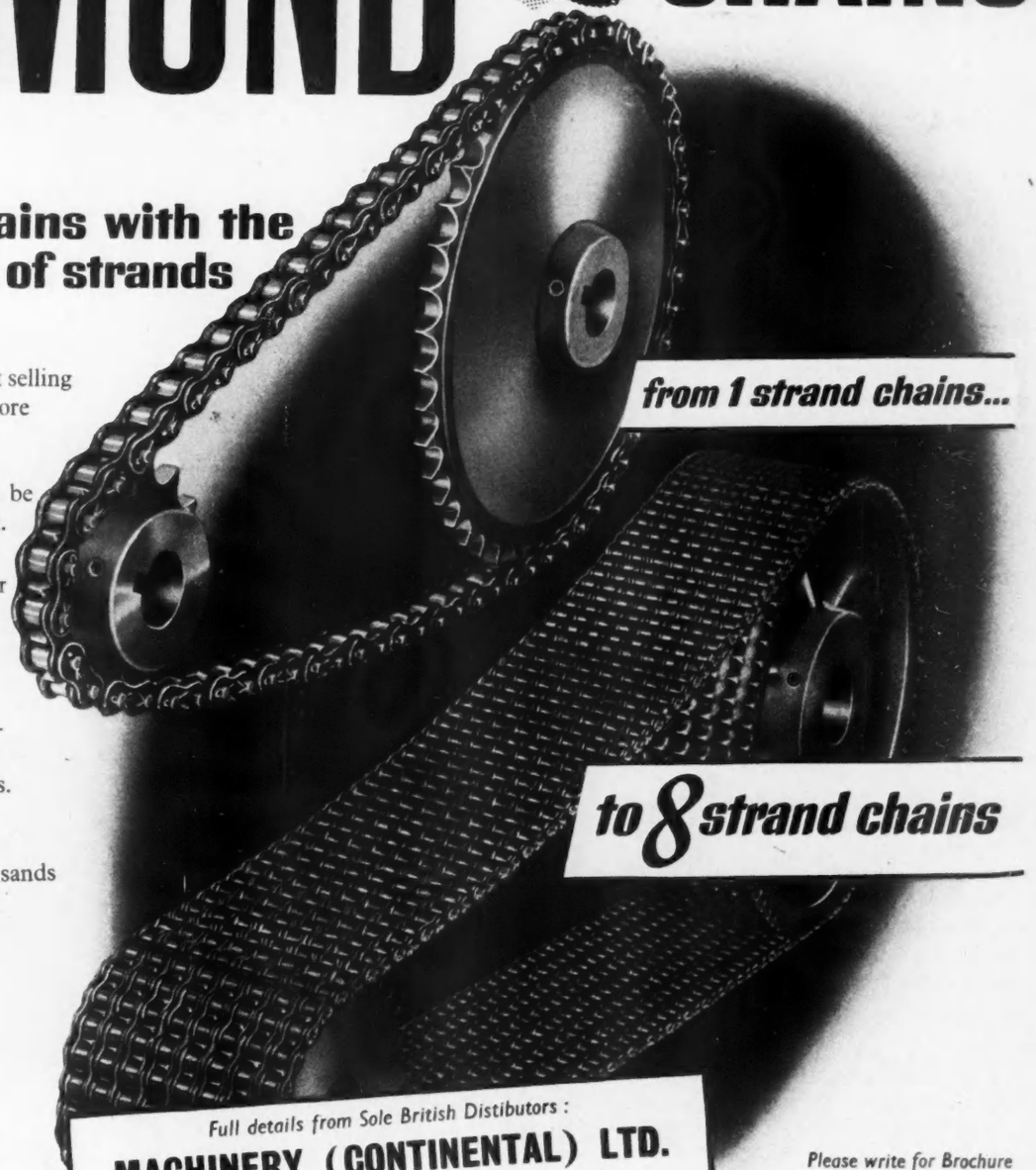

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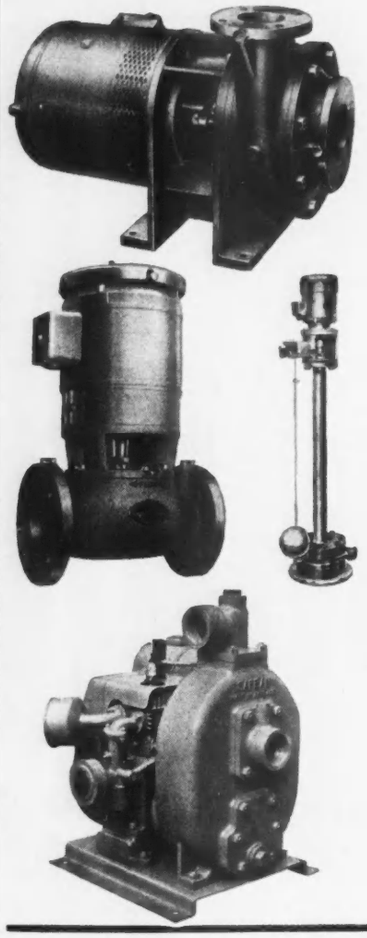

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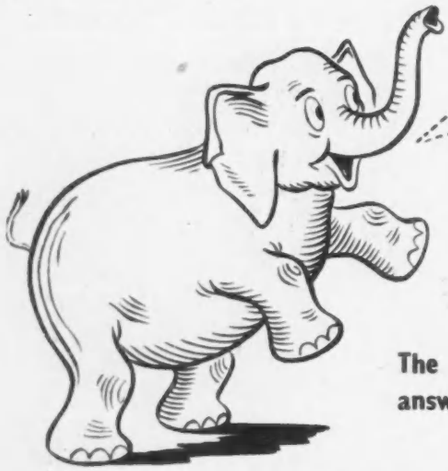

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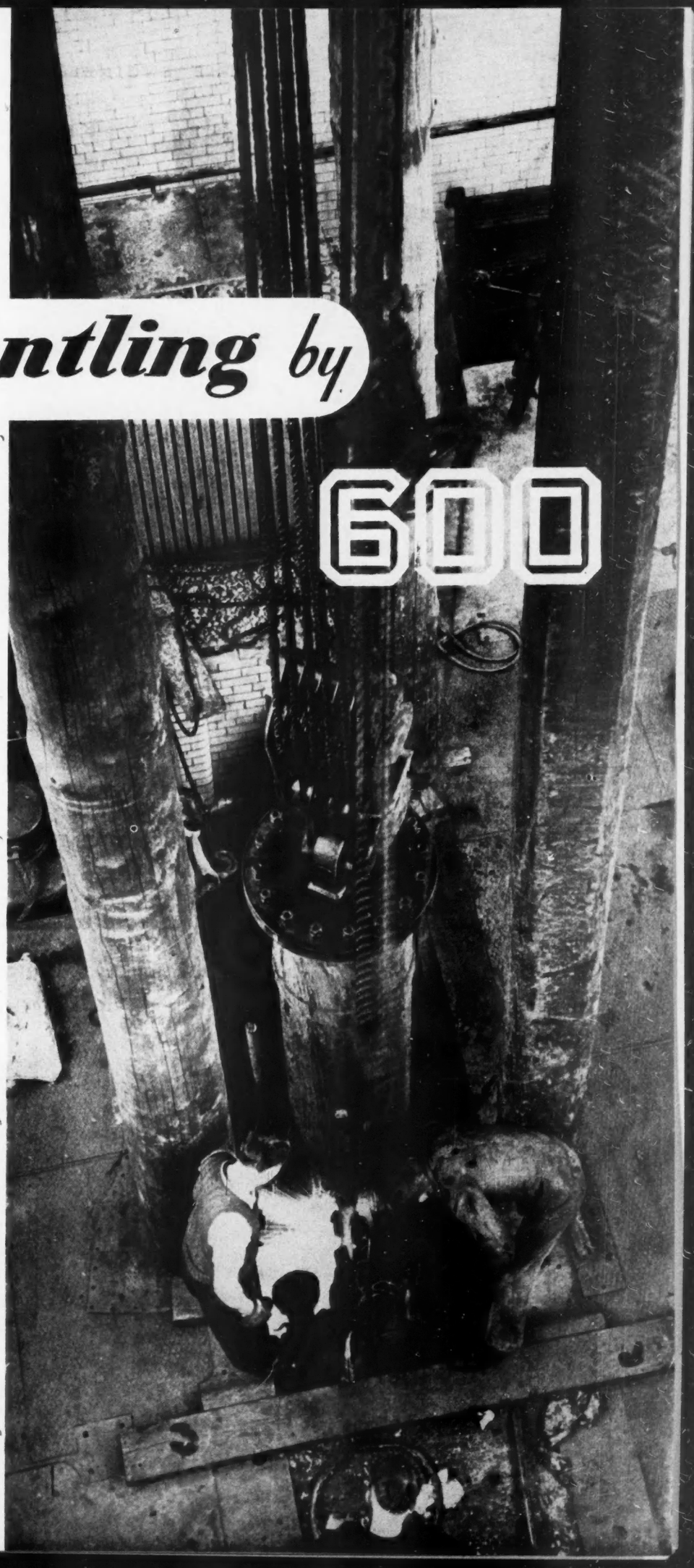

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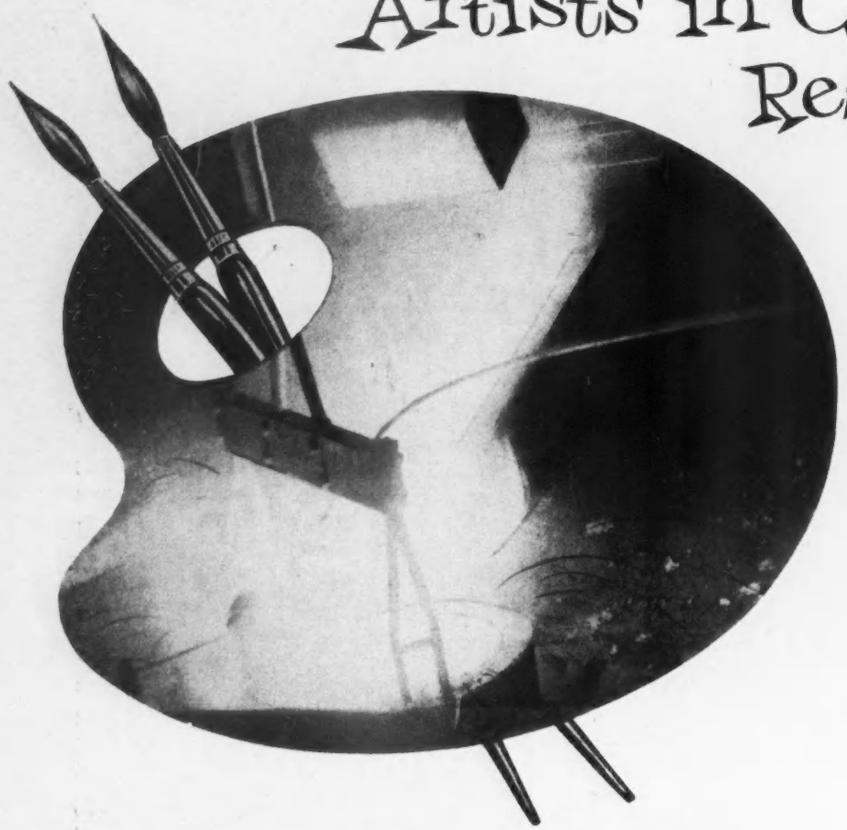

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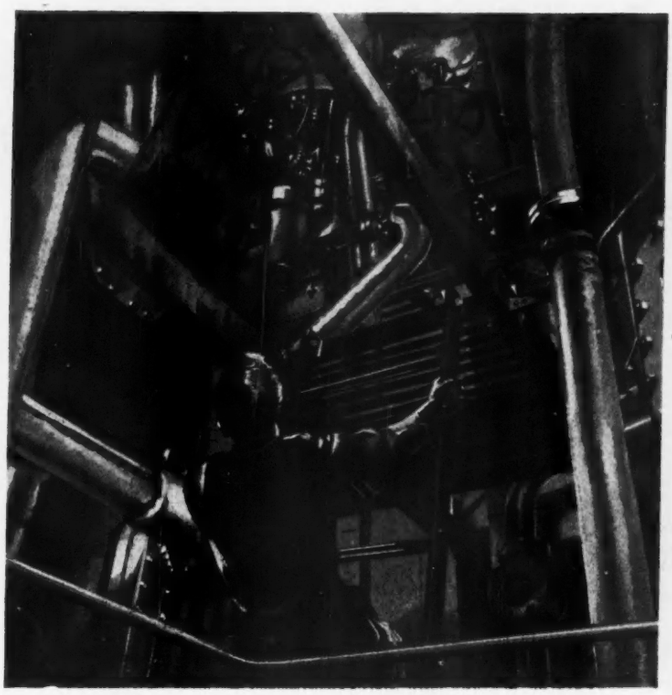

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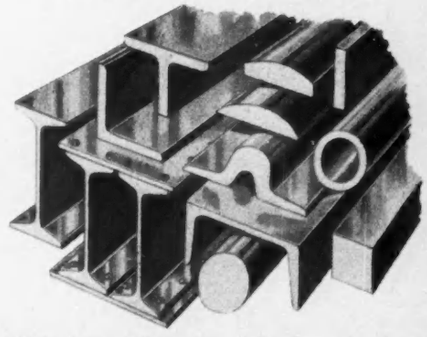

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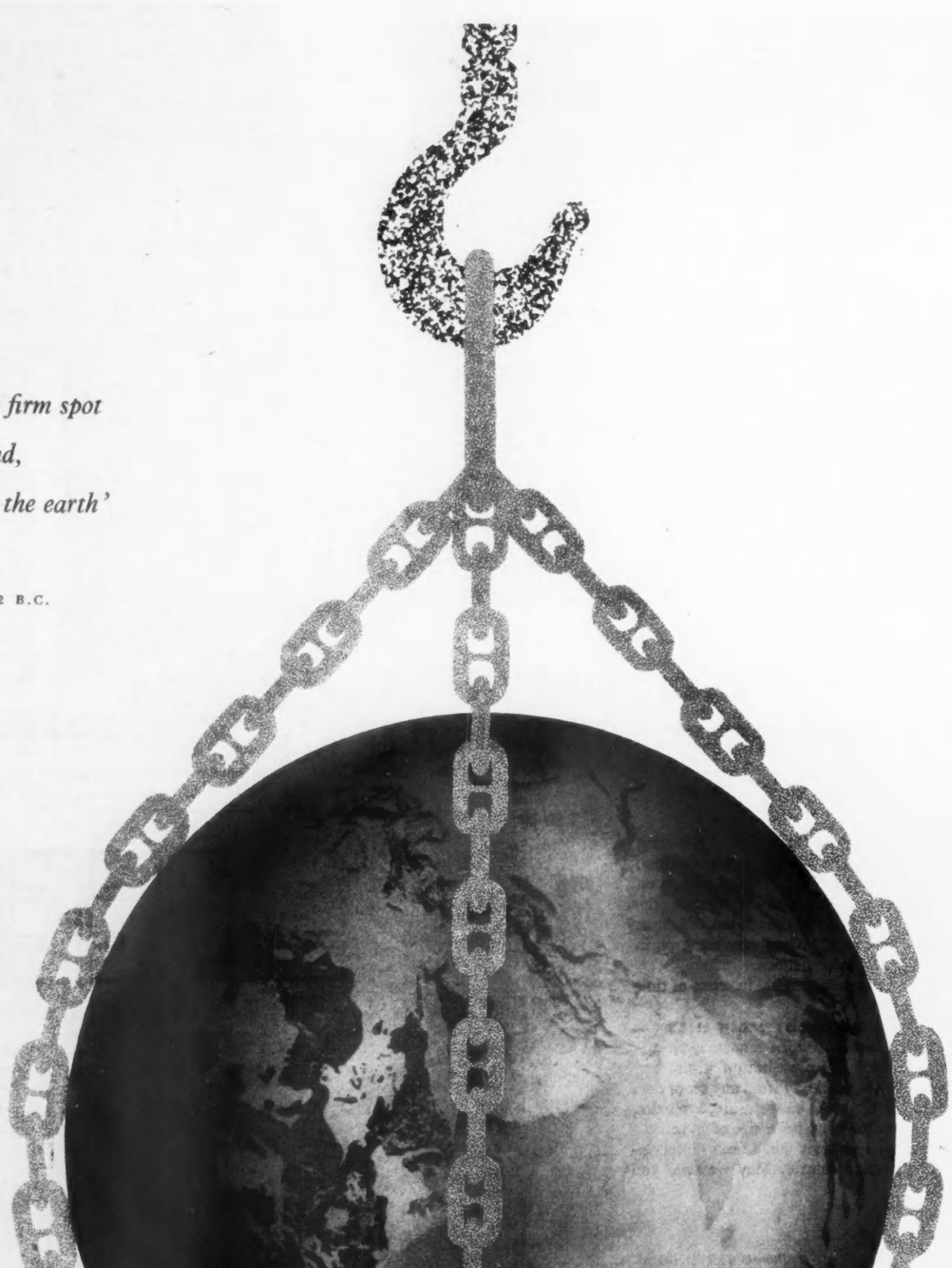

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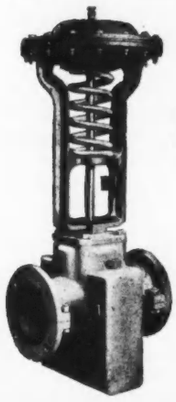

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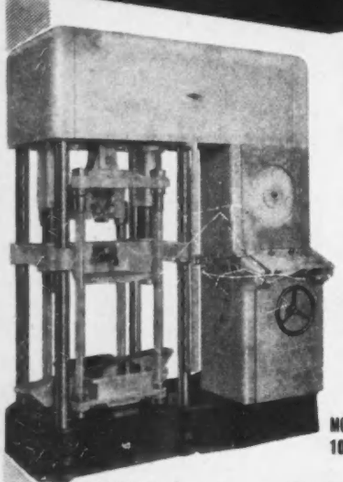

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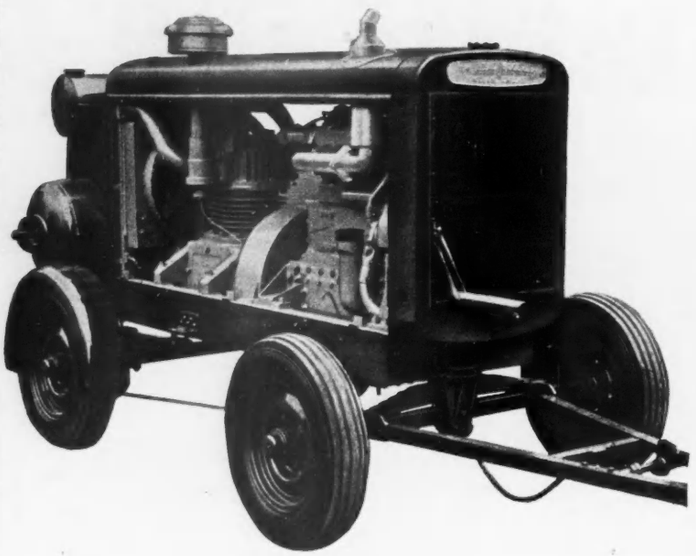

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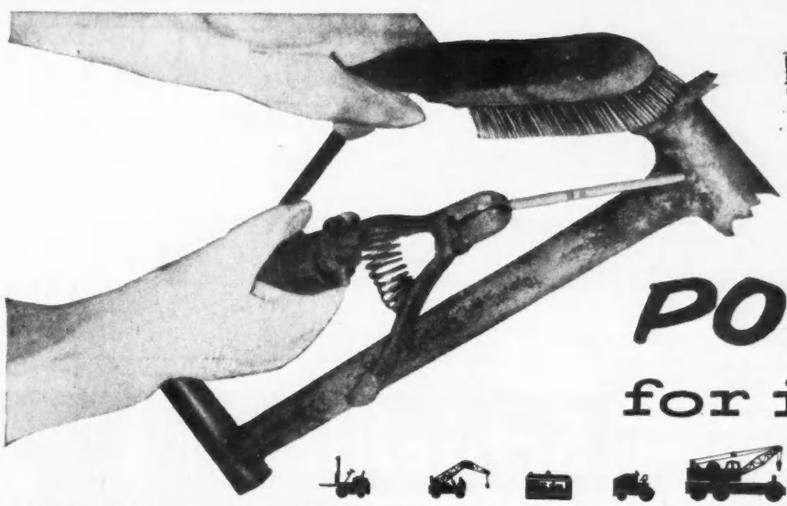

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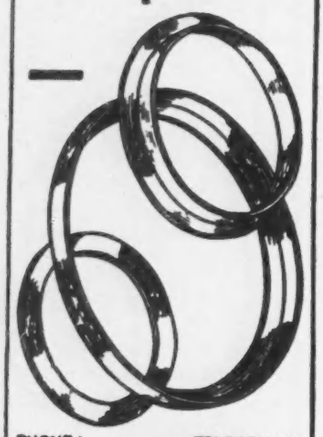

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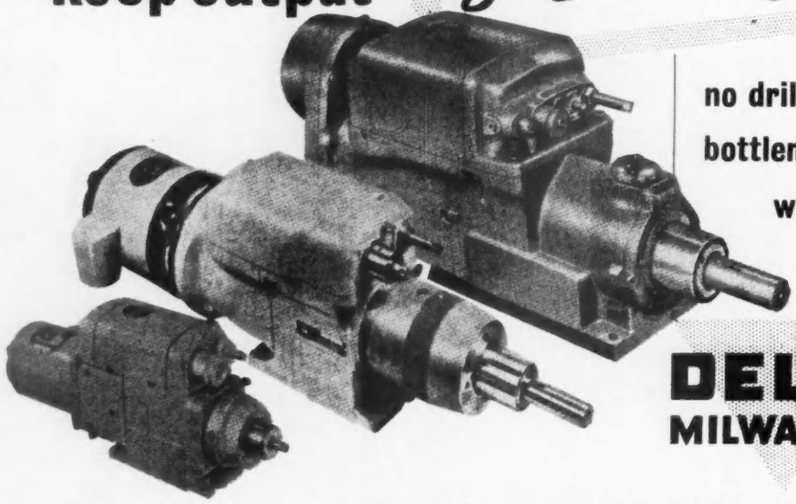

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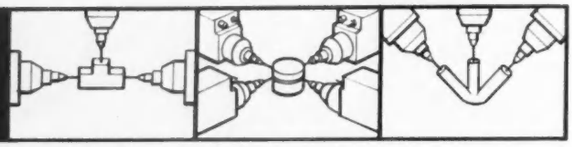

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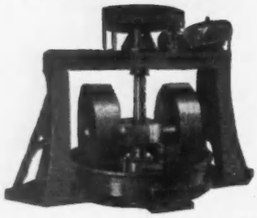

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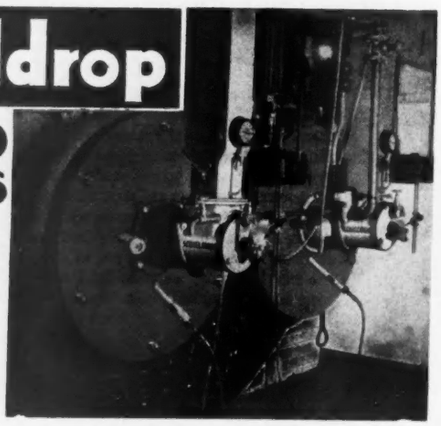

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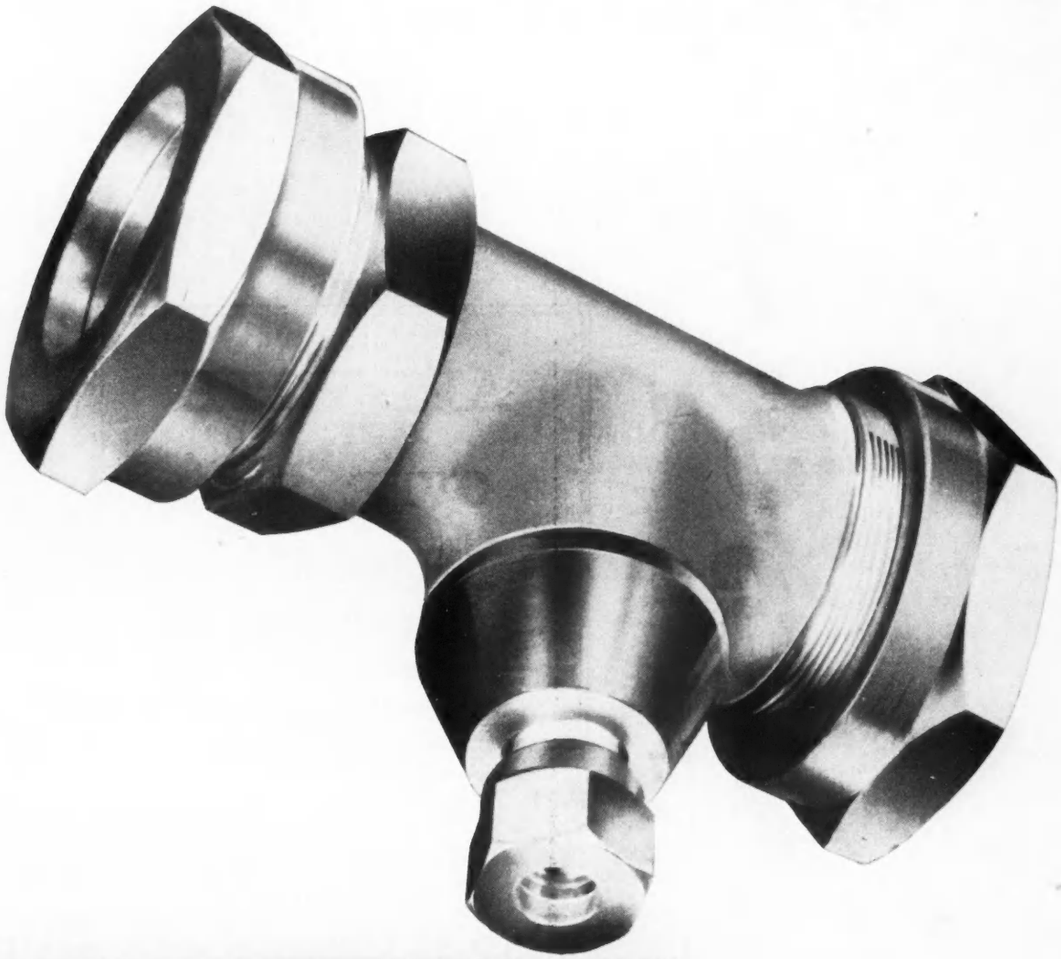

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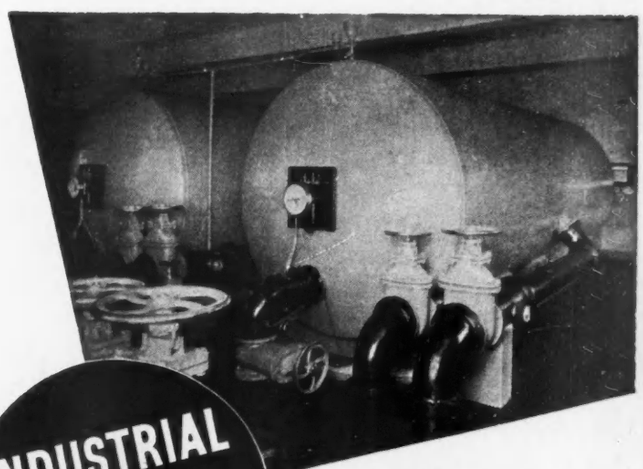

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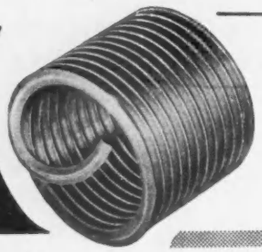

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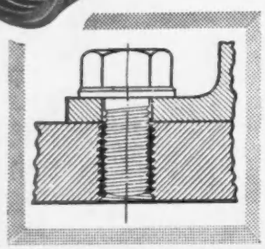

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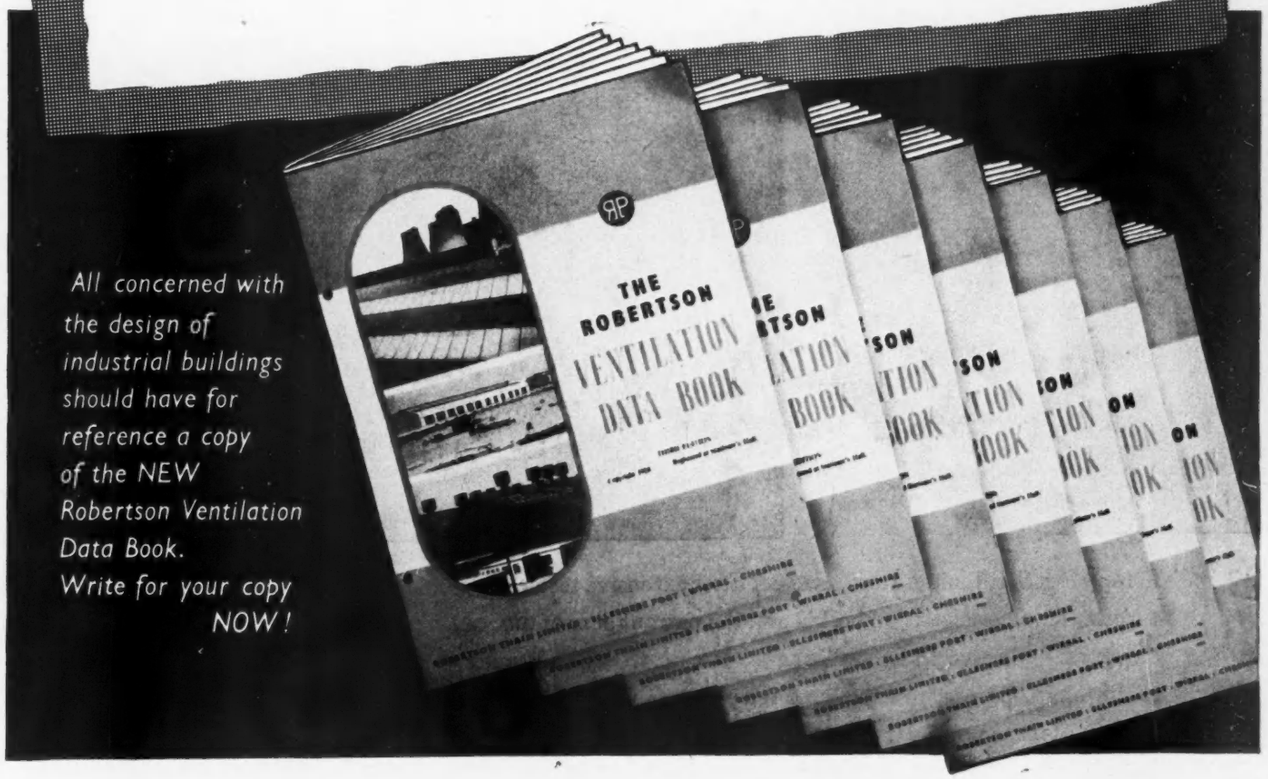

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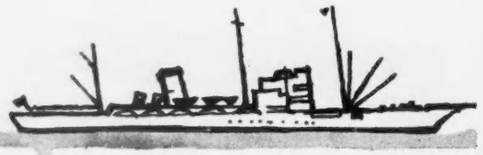

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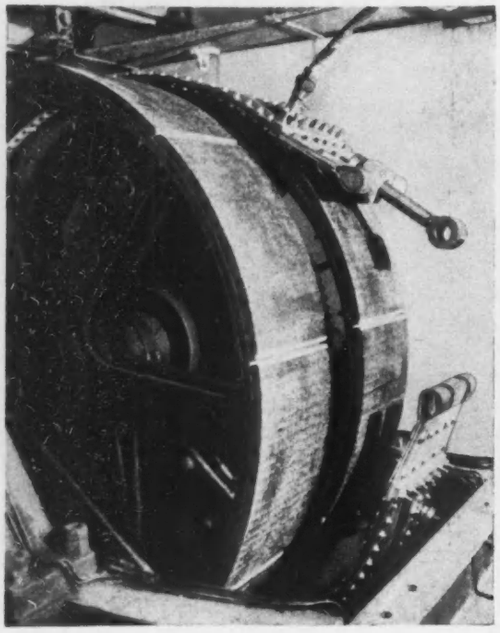

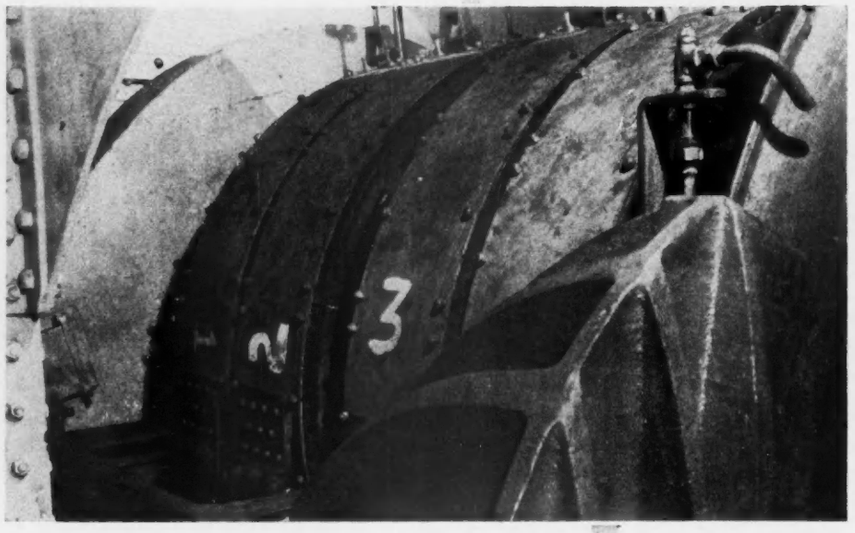

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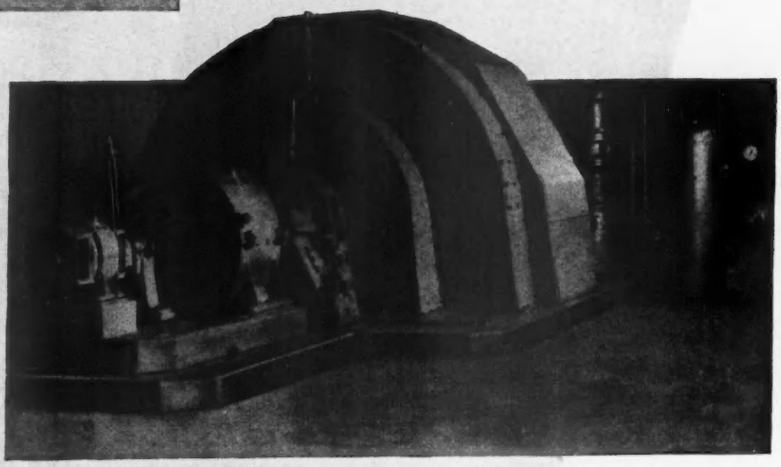

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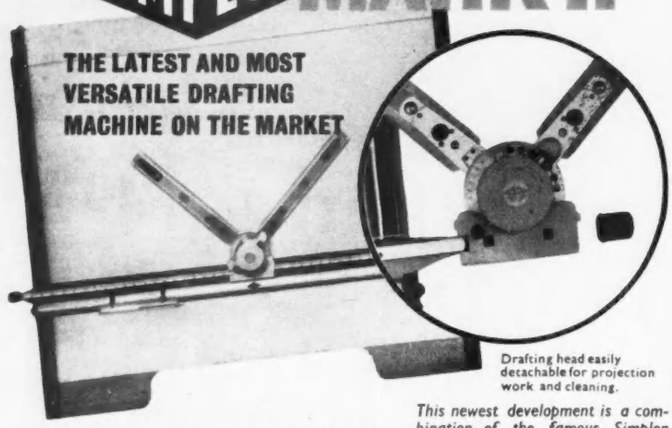

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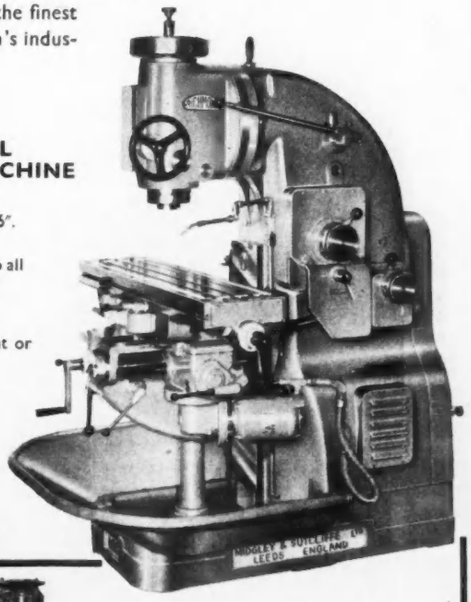

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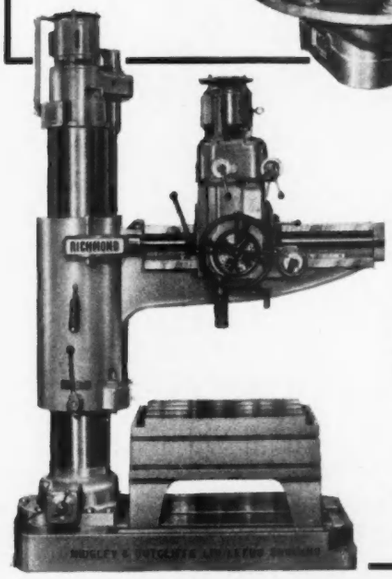

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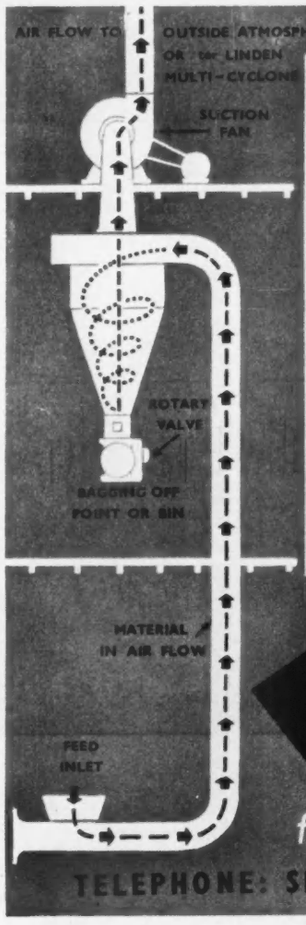

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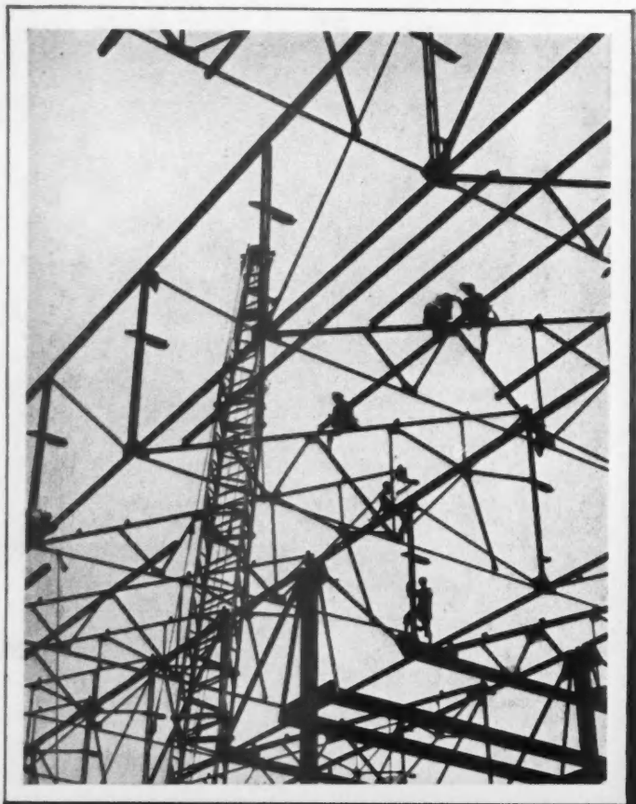

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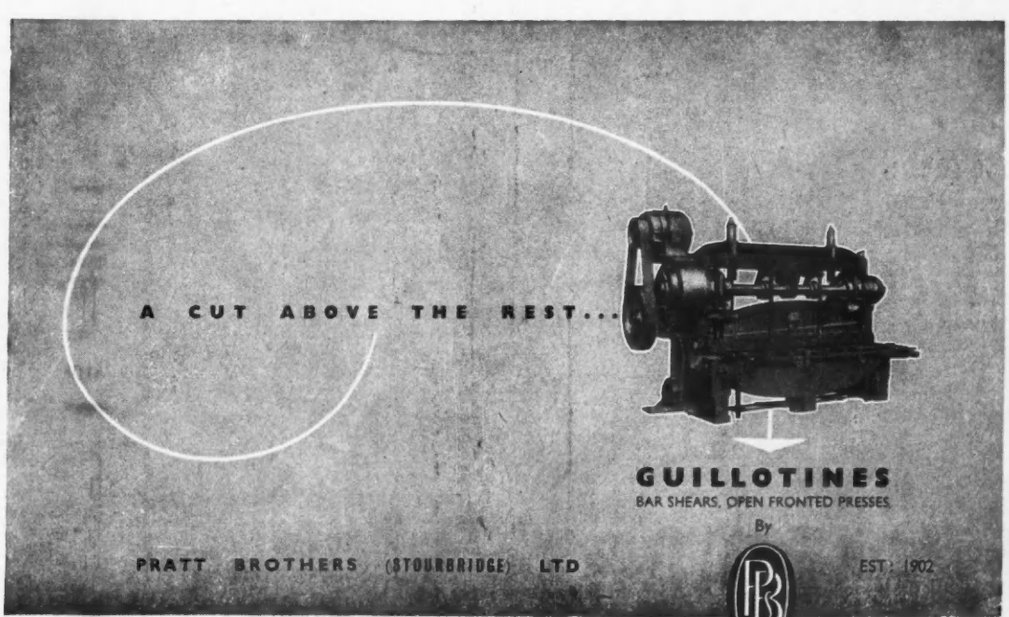

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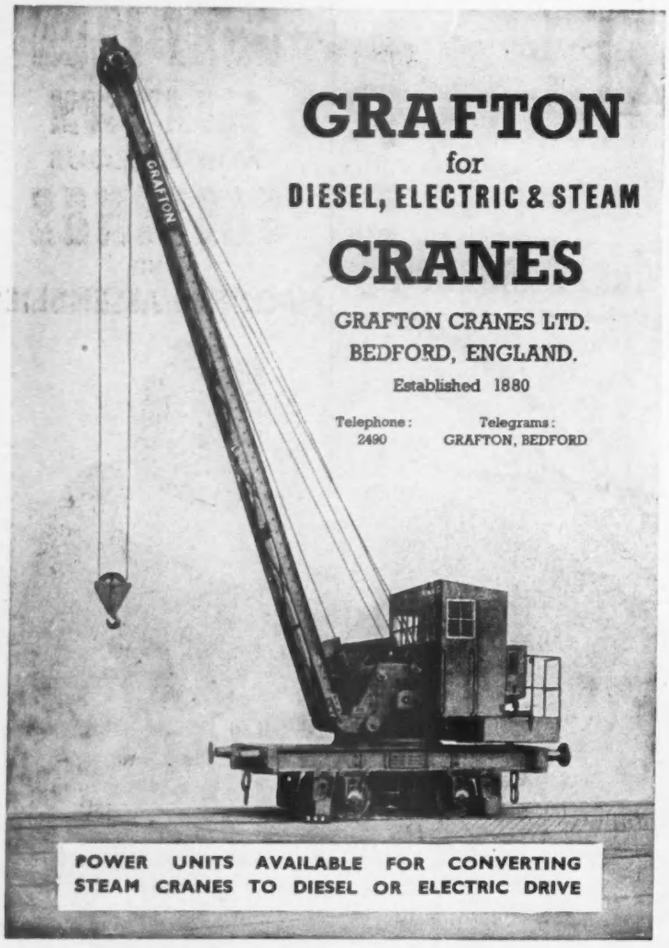

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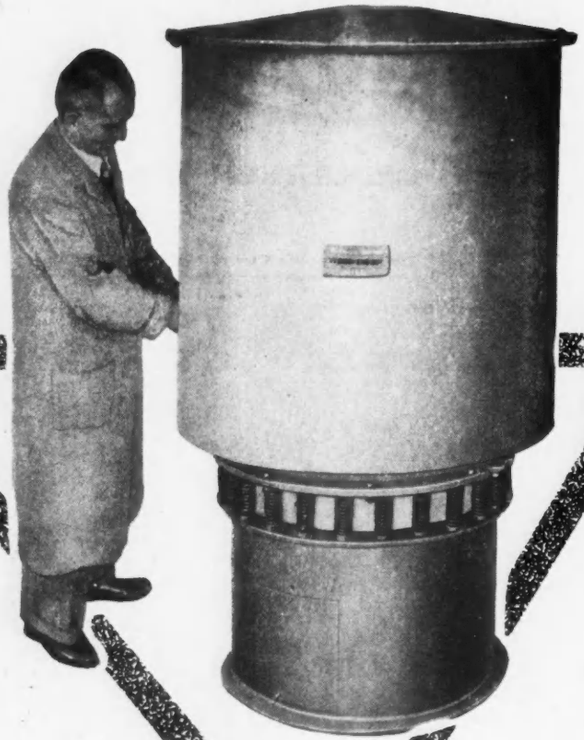

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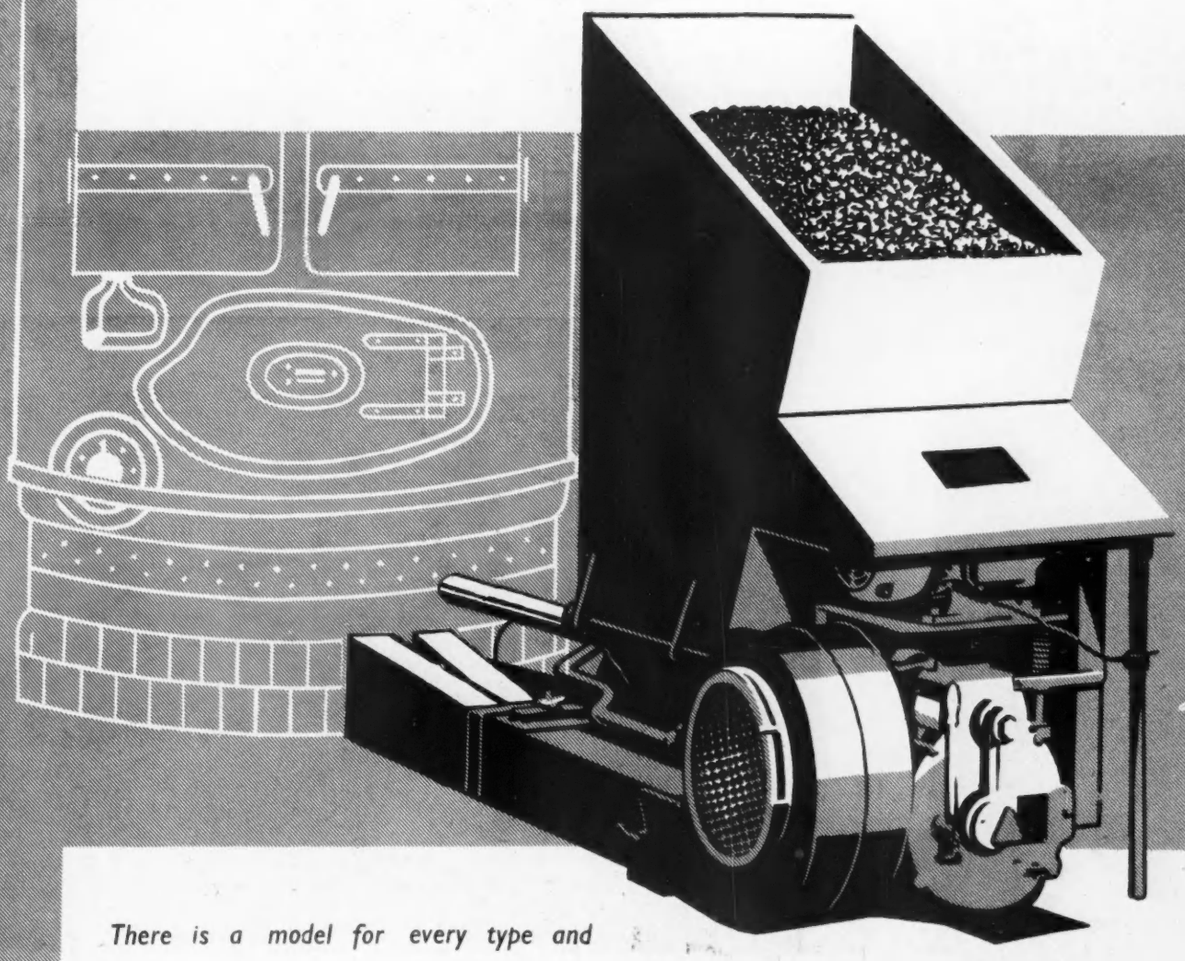

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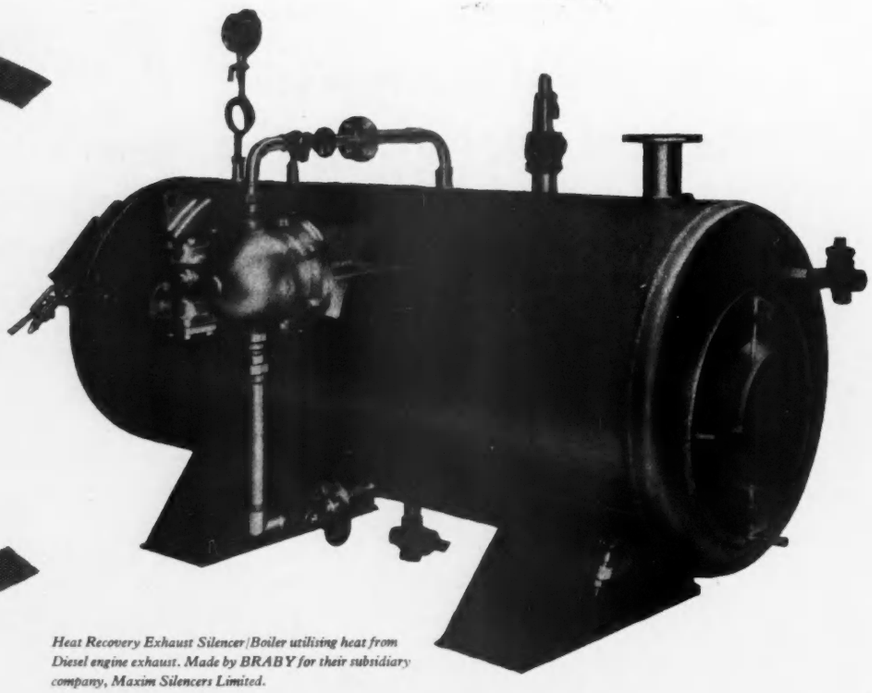

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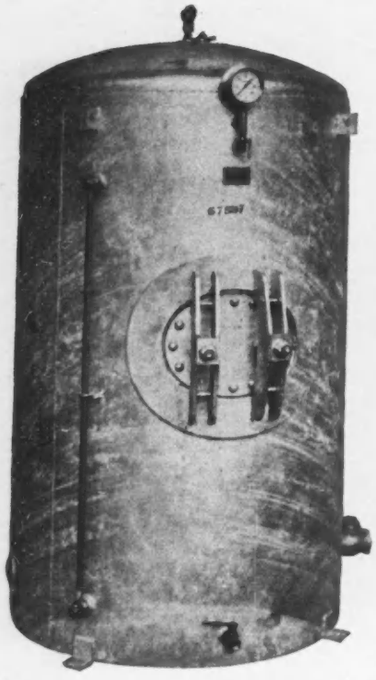

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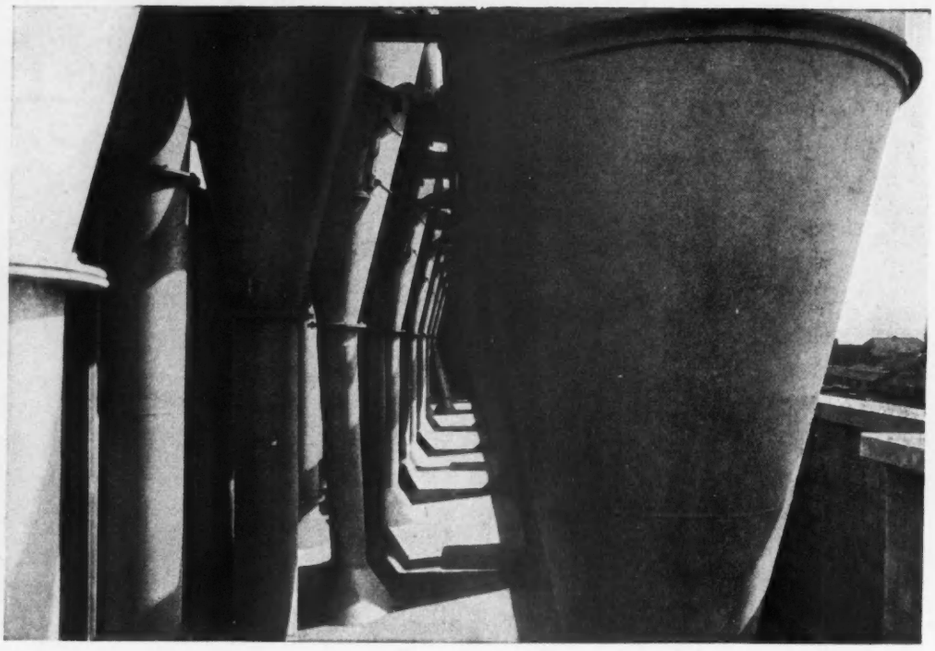

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AP139

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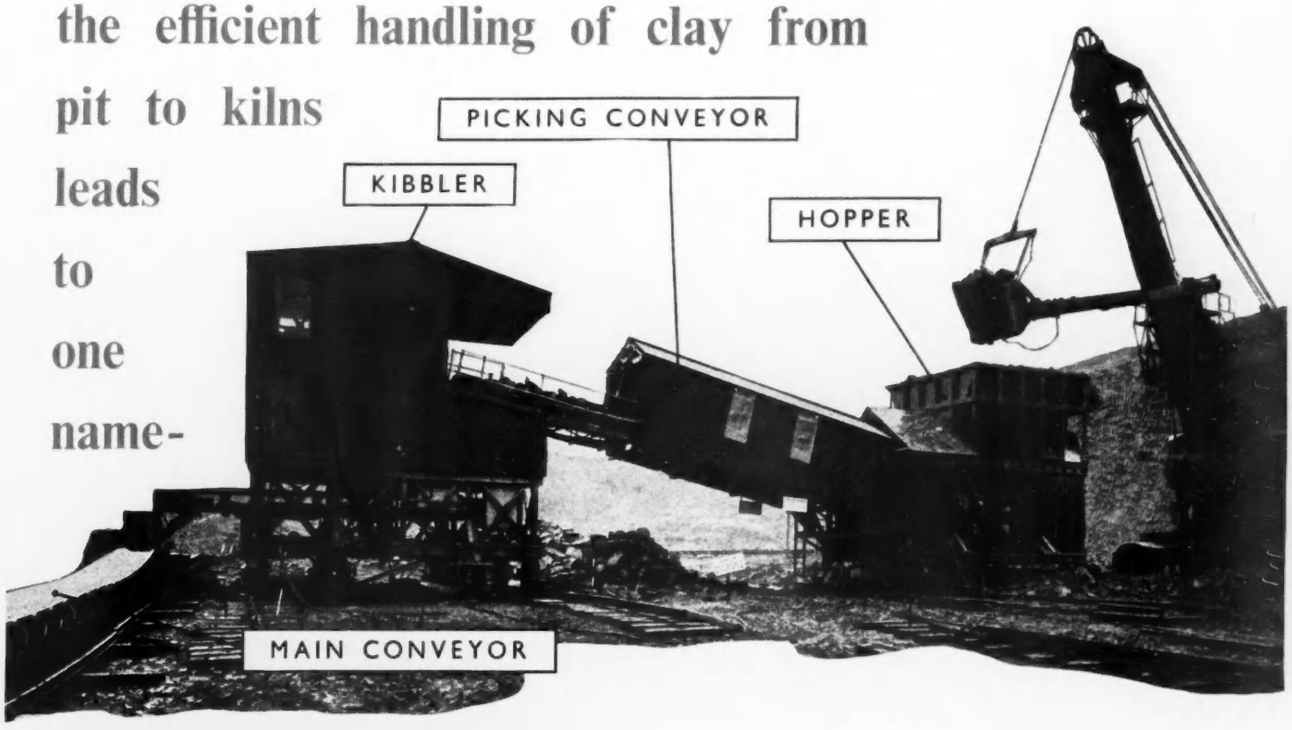

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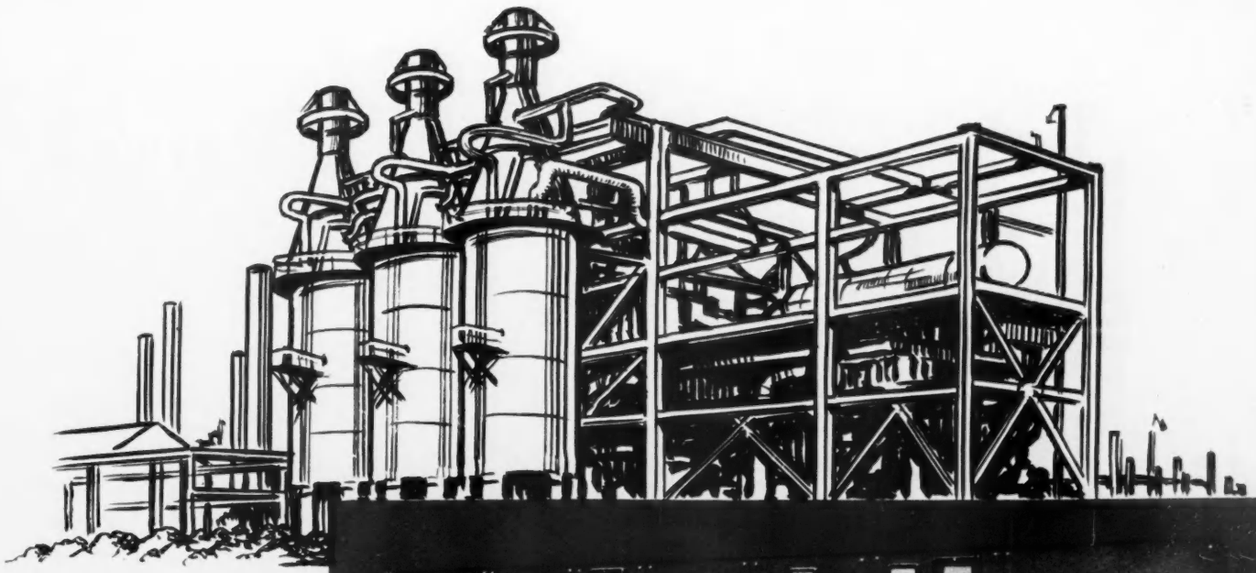

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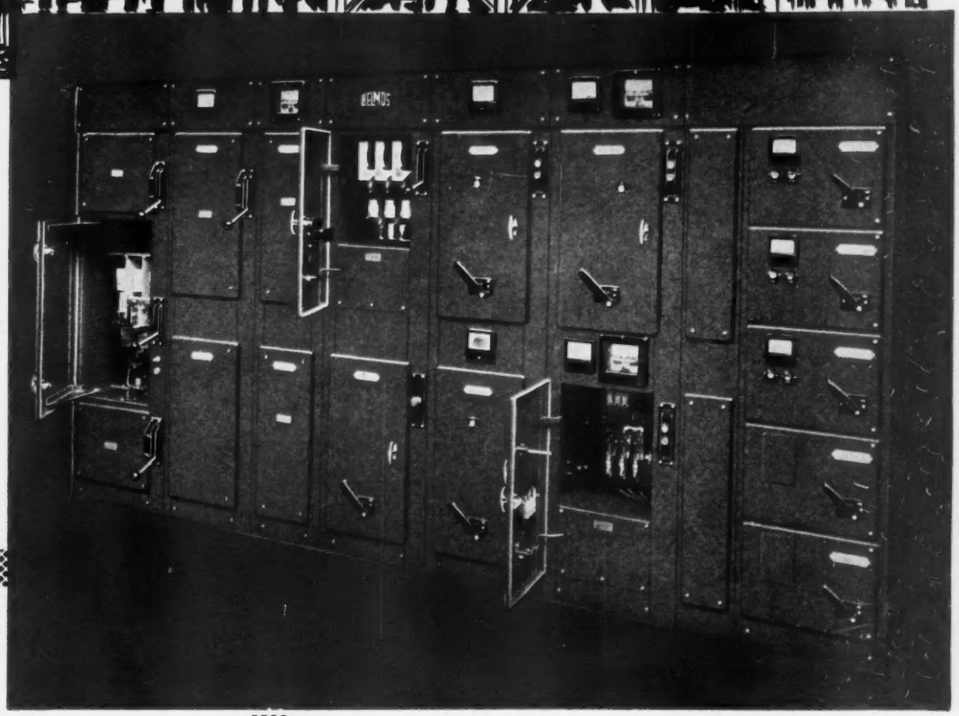

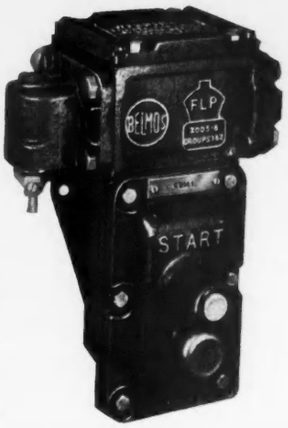

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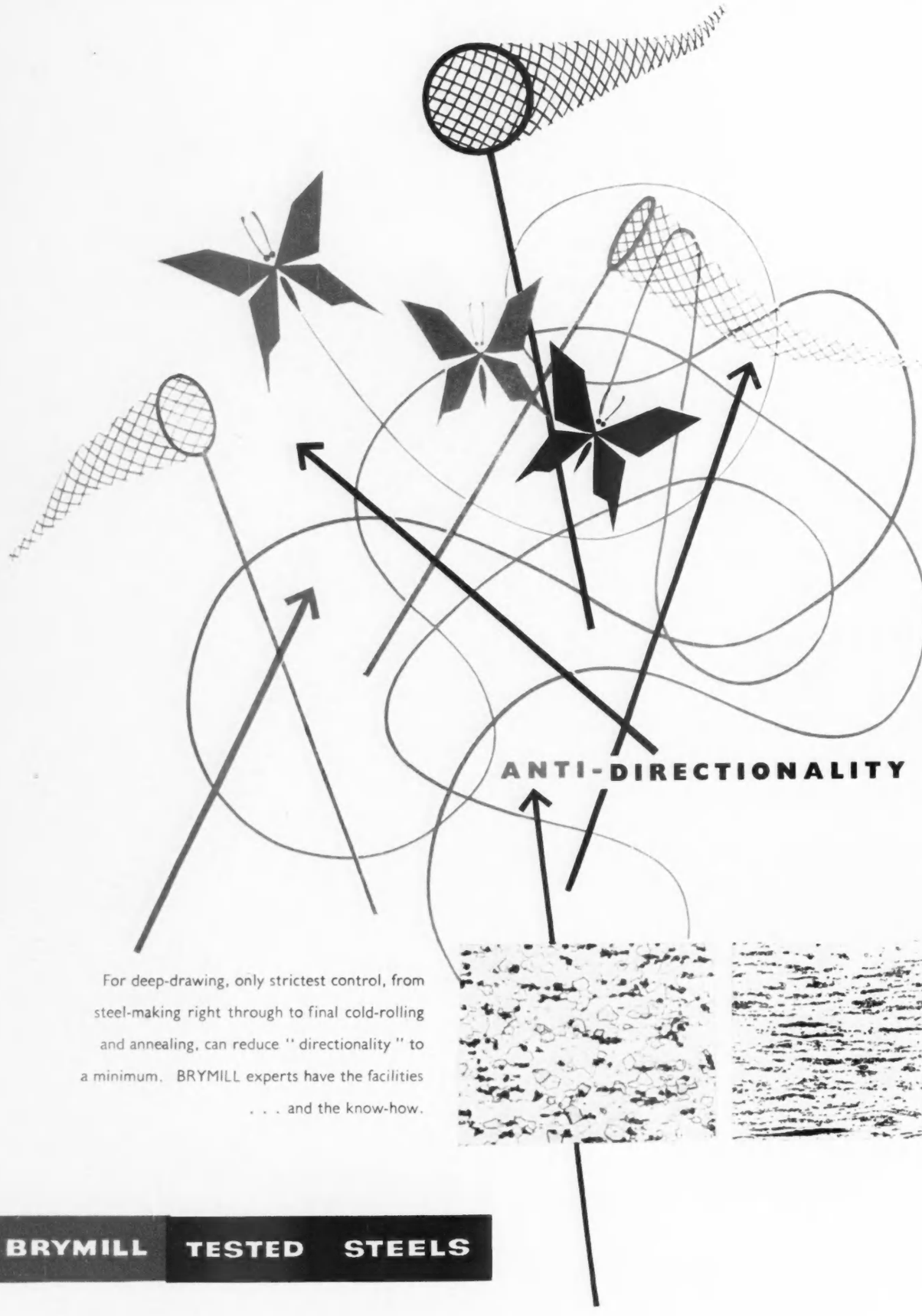

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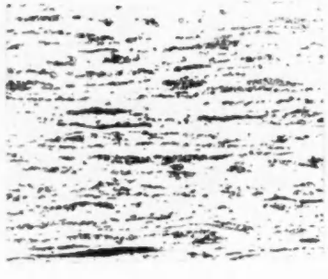

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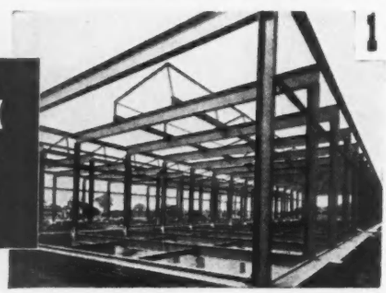

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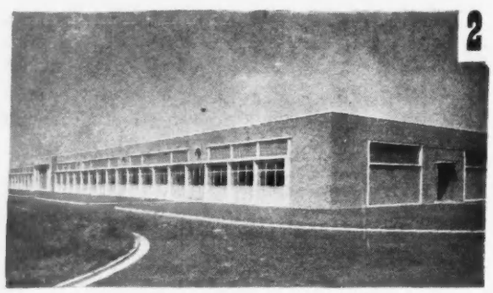

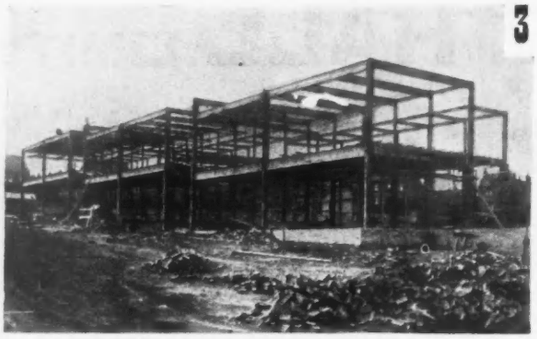

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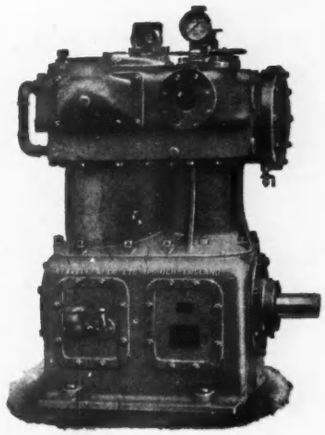

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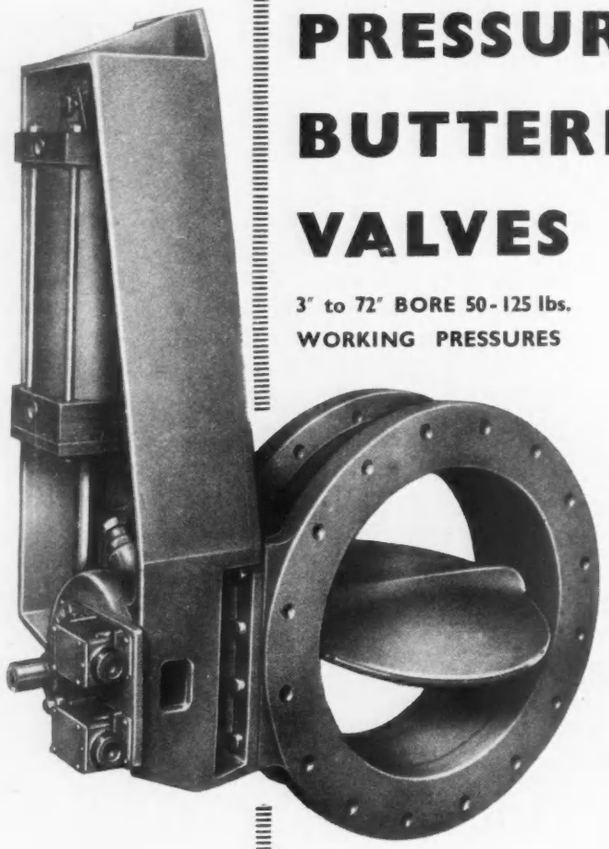

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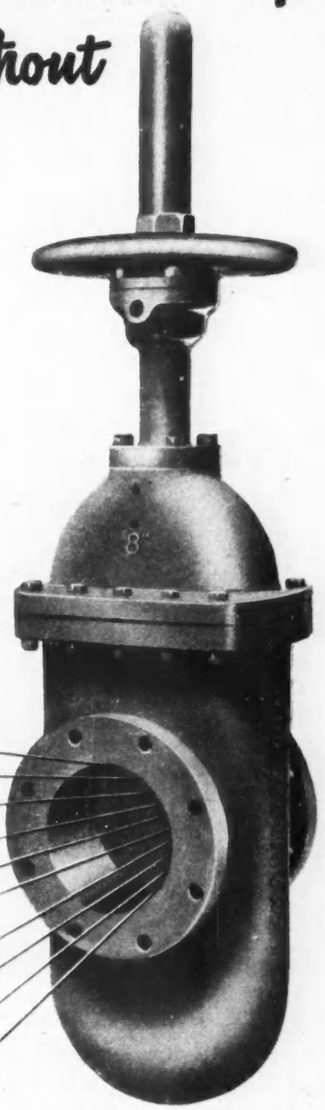

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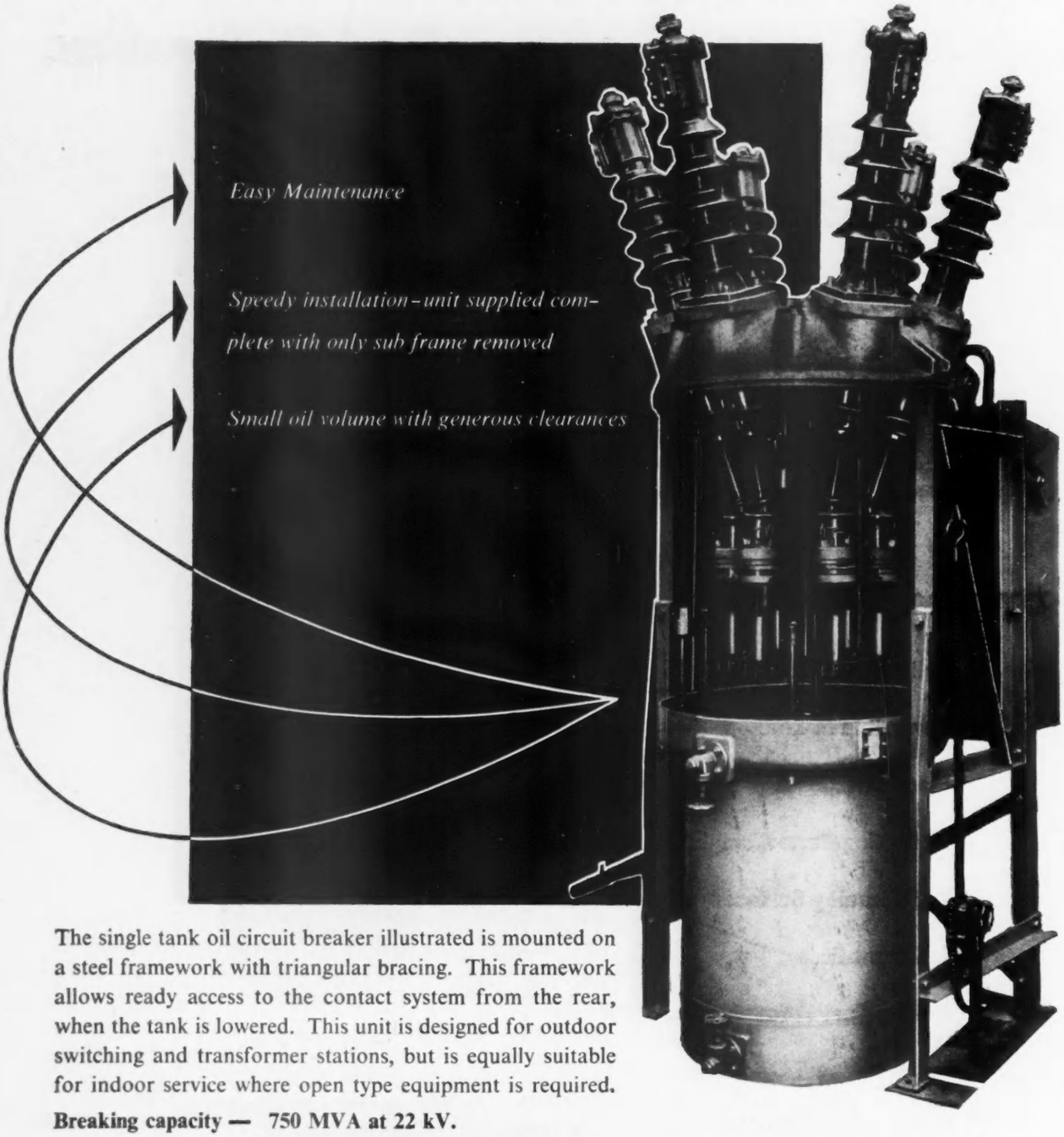
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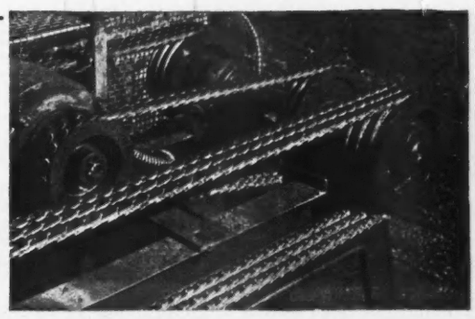

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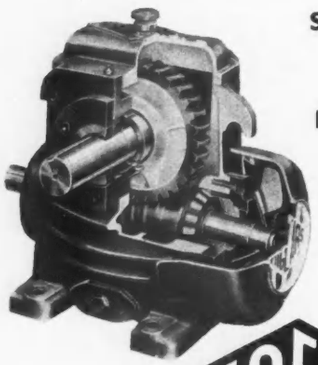

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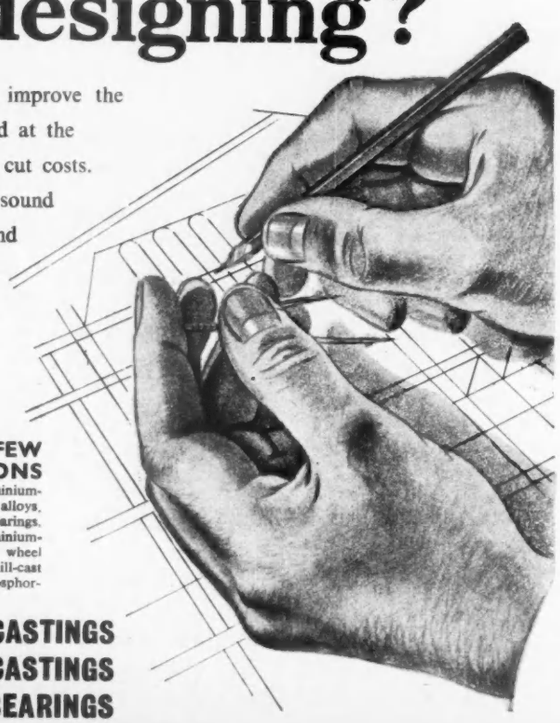

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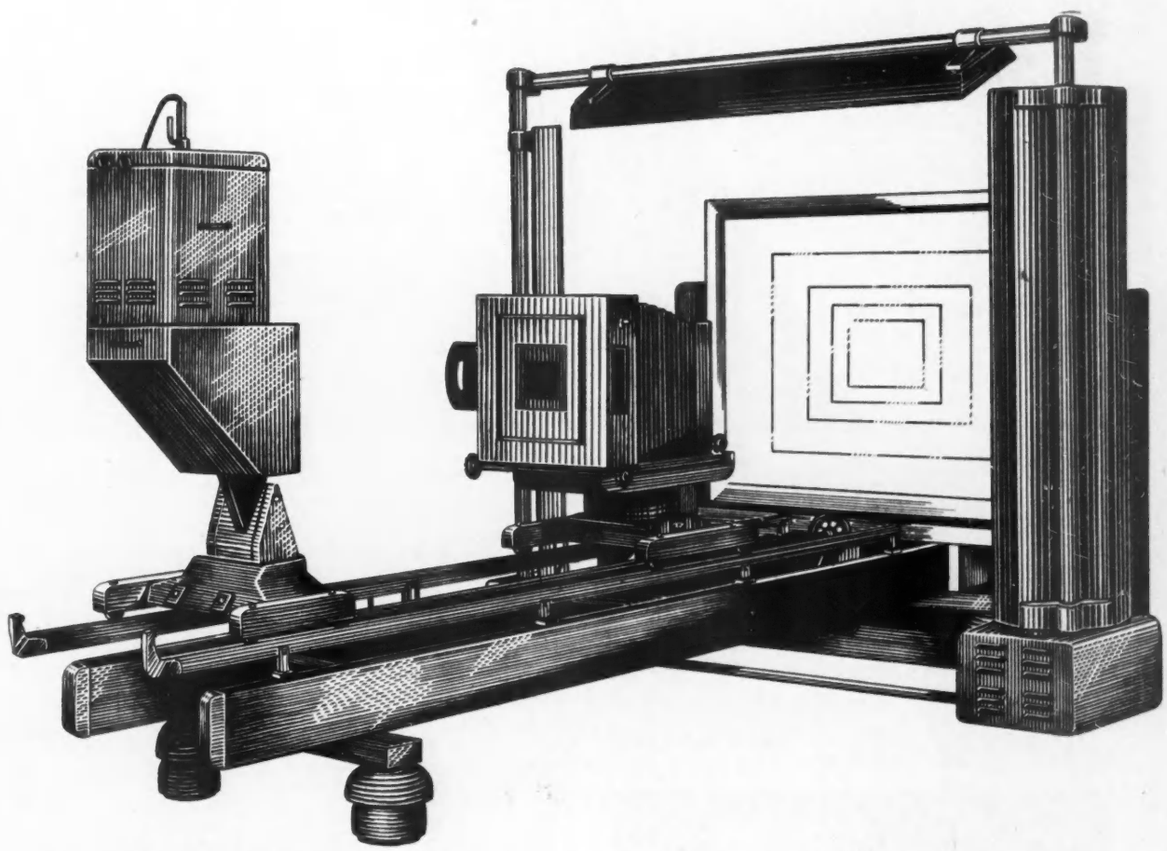

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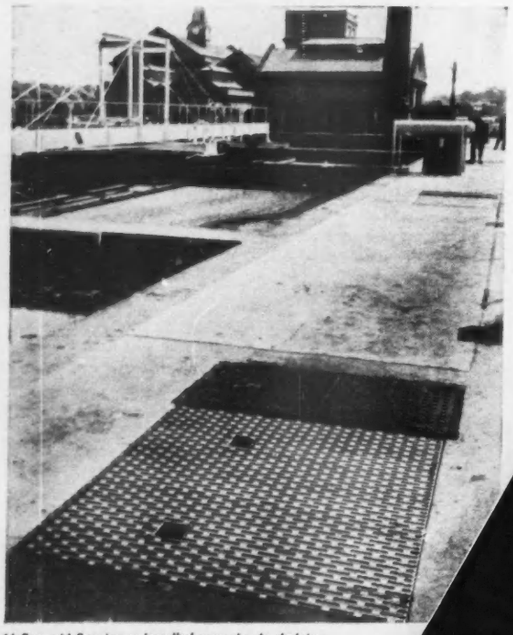

Alaflor grid flooring as installed over the de-sludging valve chambers of the sedimentation tanks at Derby Corporation reconstructed sewage disposal works. *Consulting Engineers: Messrs. J. D. & D. M. Watson. Photograph reproduced by courtesy of Mr. M. L. Francis, F.R.I.C.S., M.I.Mun.E., Borough Engineer and Surveyor*

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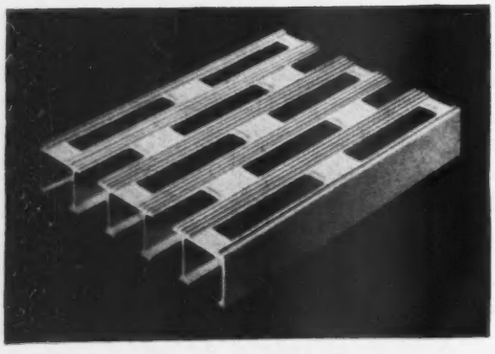

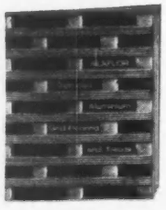

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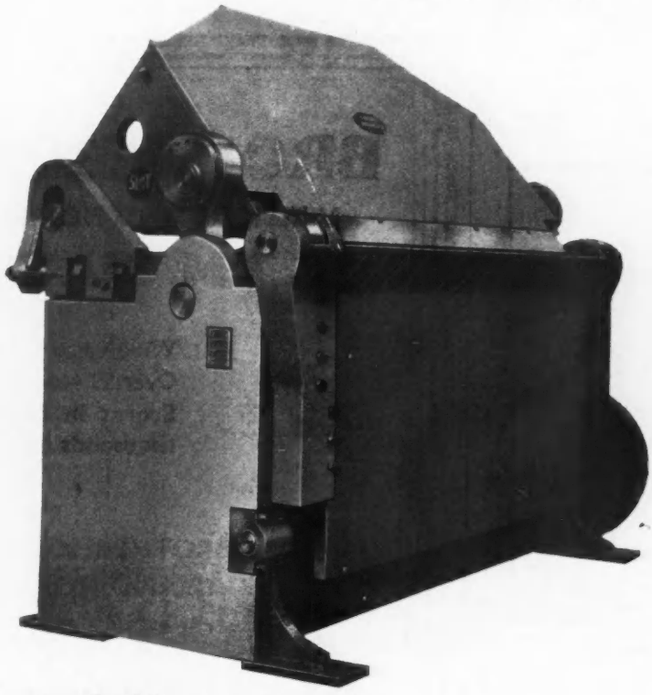

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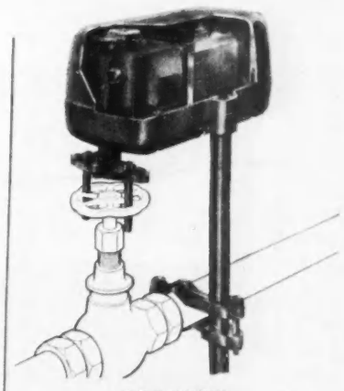

VALVE MOTORISATION by ROTORK

Rotork electric actuators can be operated by push button, or automatically from any distance.

The "Junior" model illustrated (type 1F) will operate any valve with a handwheel which a man can close with one hand. No modification to the valve is needed.

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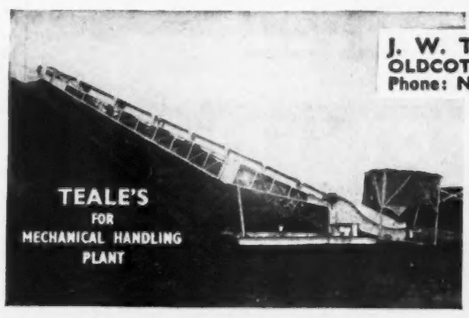

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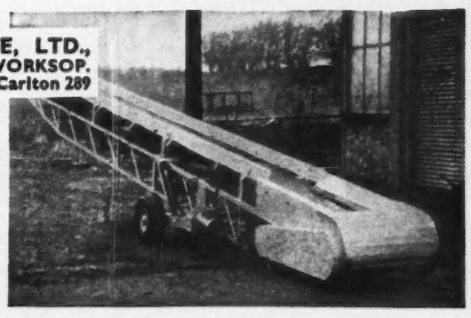

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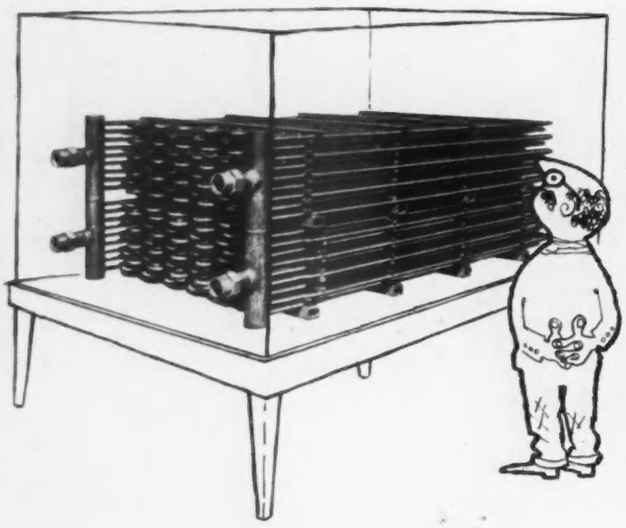

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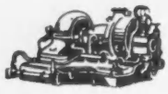

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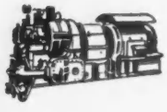

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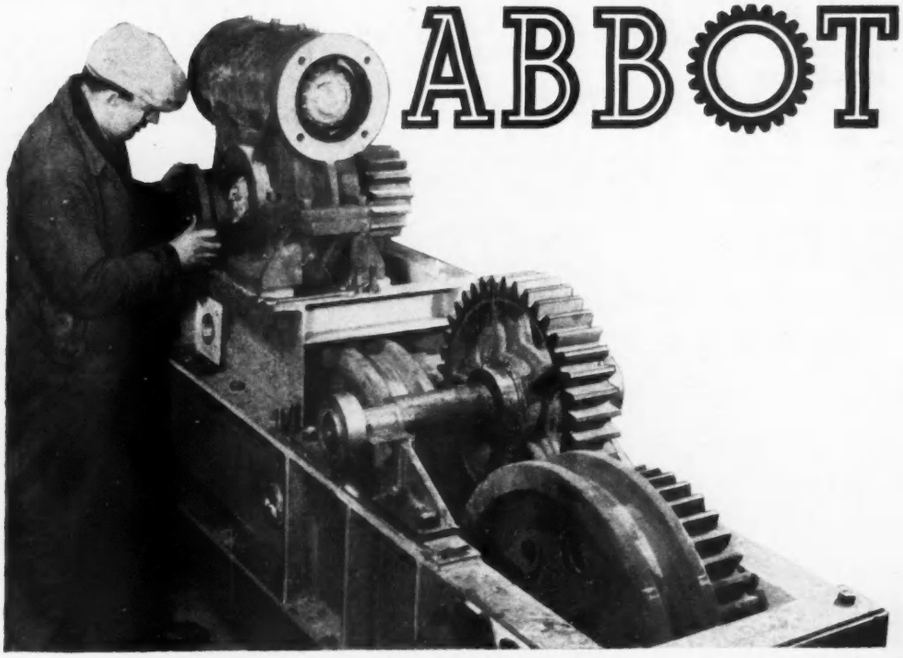

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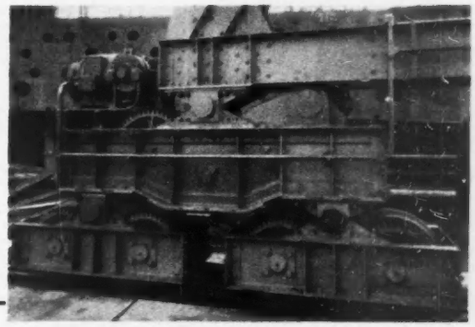

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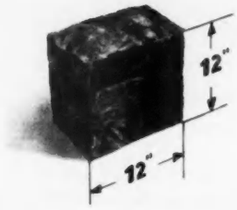

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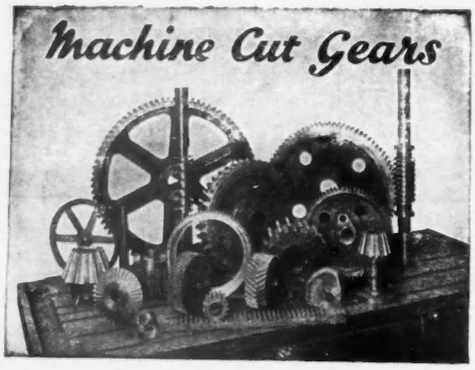

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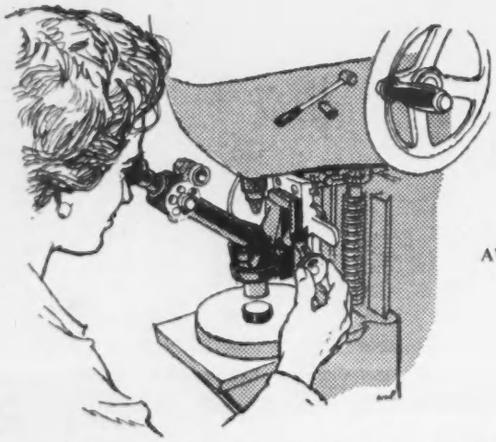

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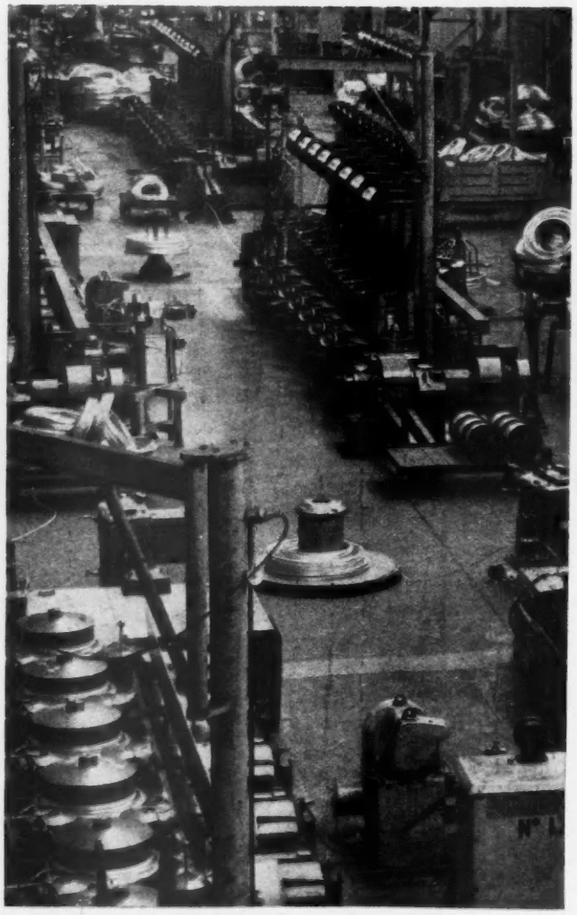

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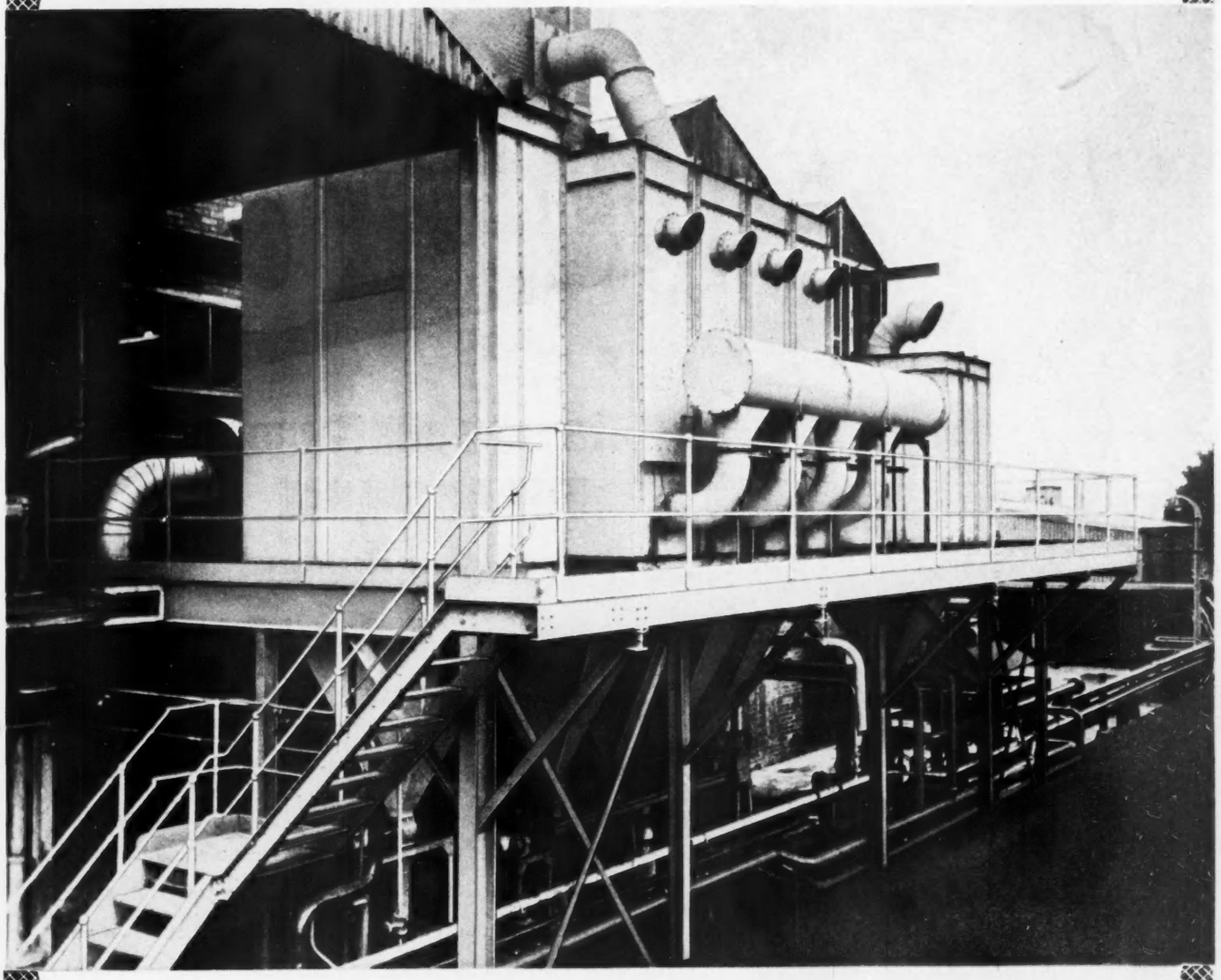
AP52

Chemical Engineers Choose TILGHMAN'S LIMITED Automatic Bag Filters



On the plant recently installed by Simon Handling Engineers, Ltd., for Imperial Chemical Industries, Ltd., Clitheroe, Tilghman automatic bag filters were chosen to remove and contain the very fine oxide powders from various mixing, pelletising and process handling points, etc.

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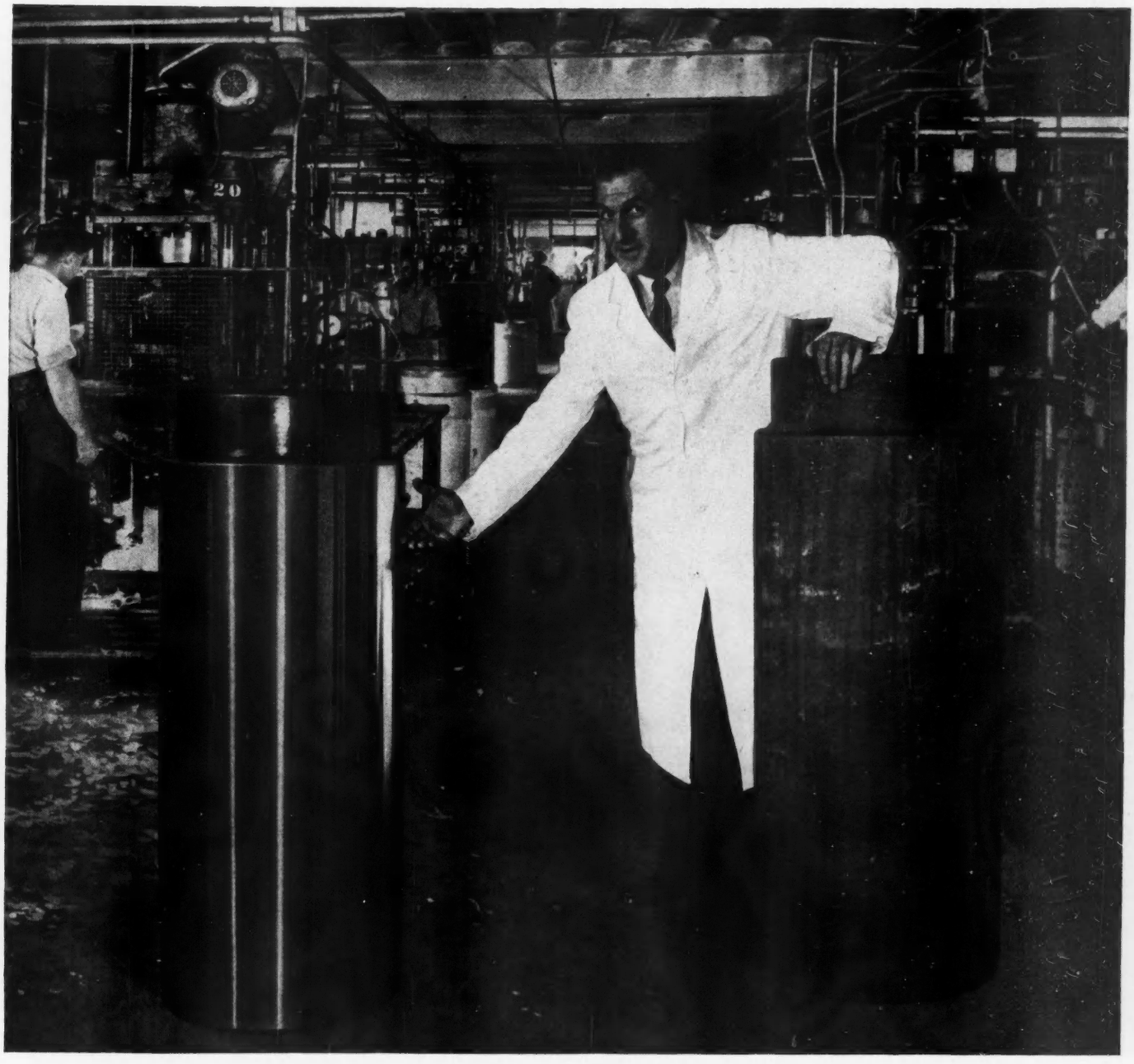

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Here's the perfect before and after story of the Fescol process. The ram on my left is untreated, and has become corroded and pitted by wear and corrosion, in this condition it has reached the end of its useful life. Now look at the other ram, it was just the same before it was 'Fescol'-ised and now it will retain its new look almost indefinitely. That's because the nickel or chromium protection provided by the Fescol process withstands wear and corrosive attack being an even harder, more durable surface than the original metal. The process has proved so successful in the salvage of worn rams that now we have them treated before installation. Then we more or less forget about them.

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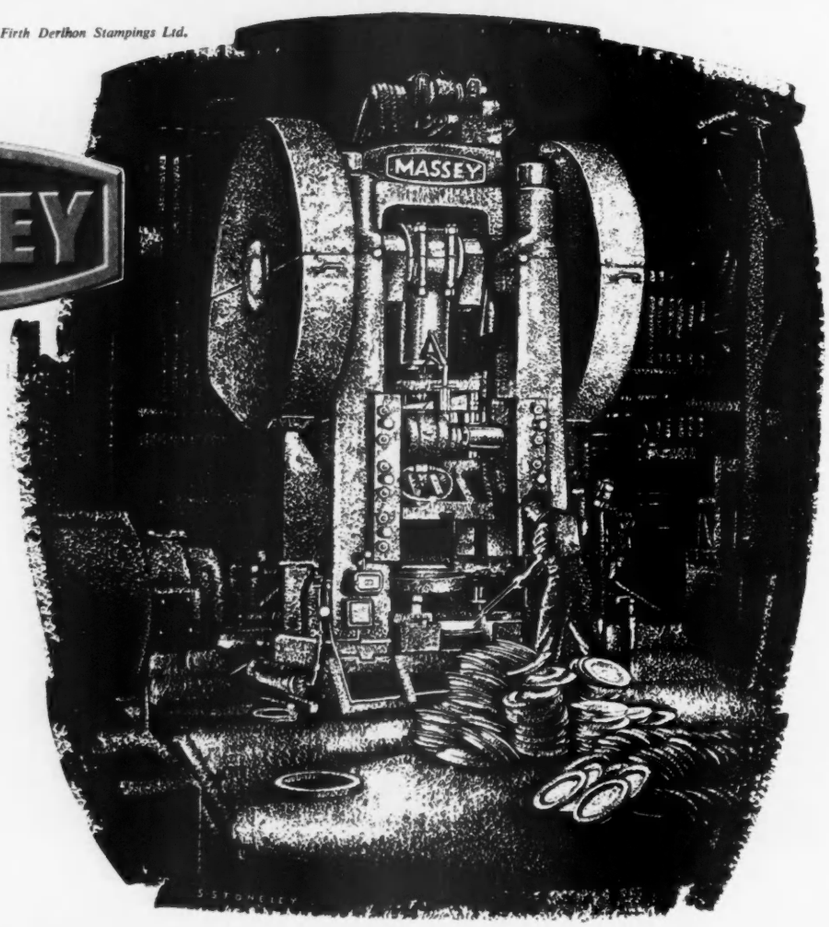

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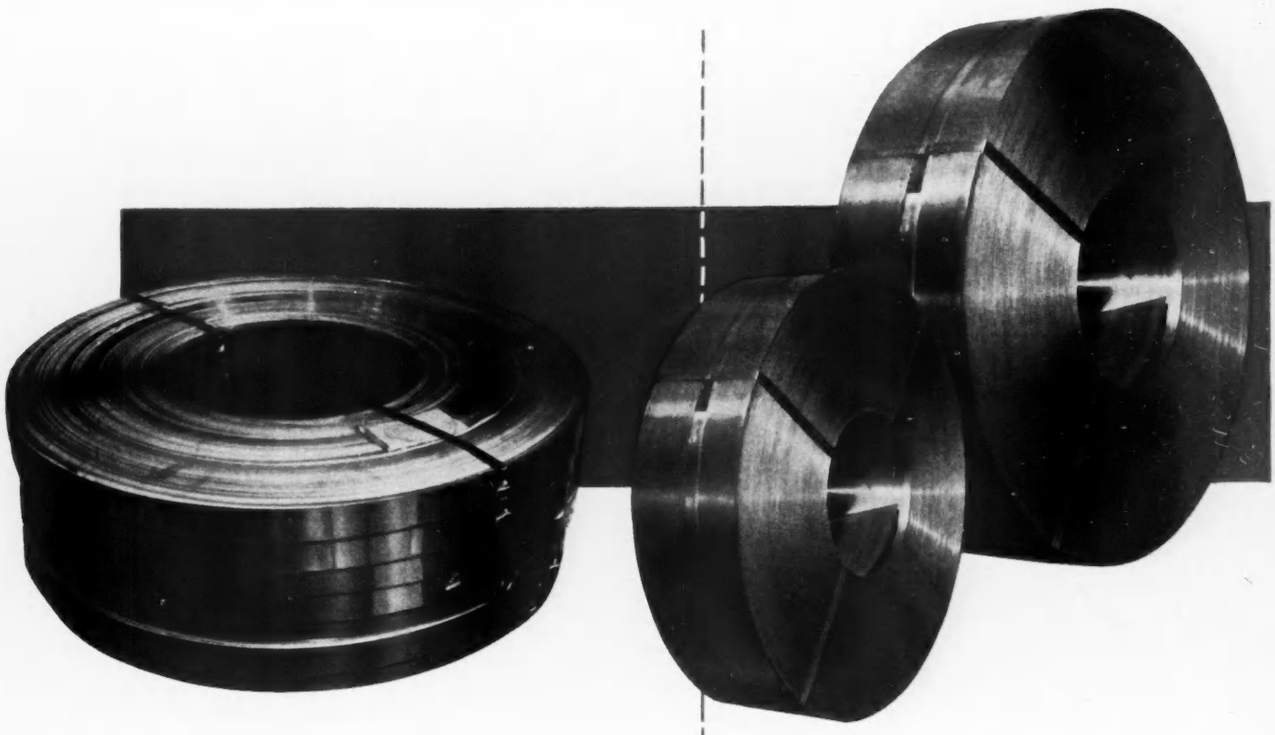

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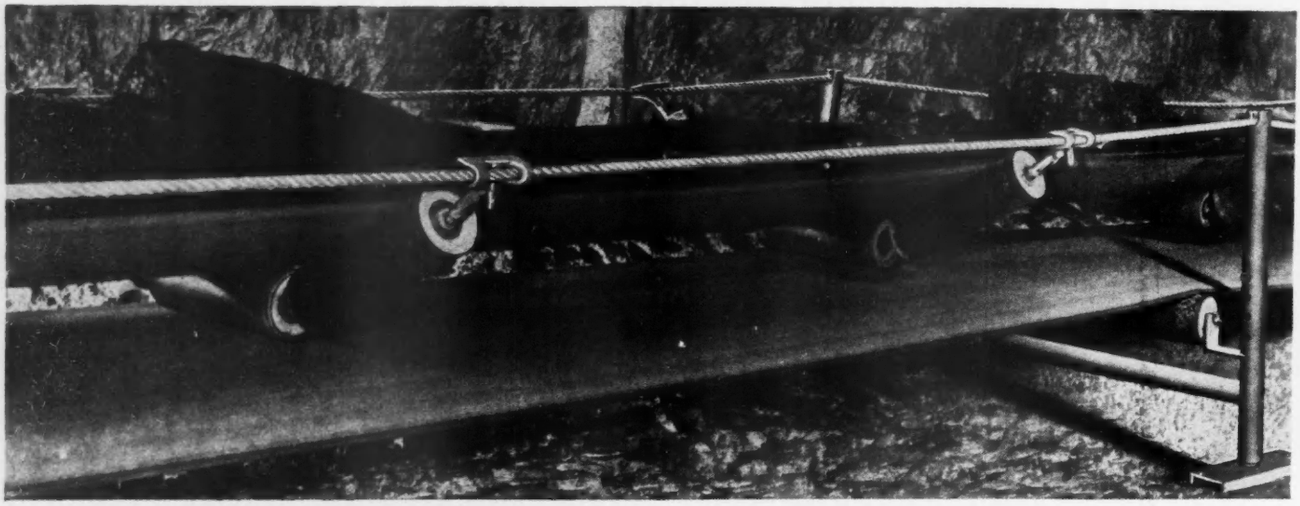

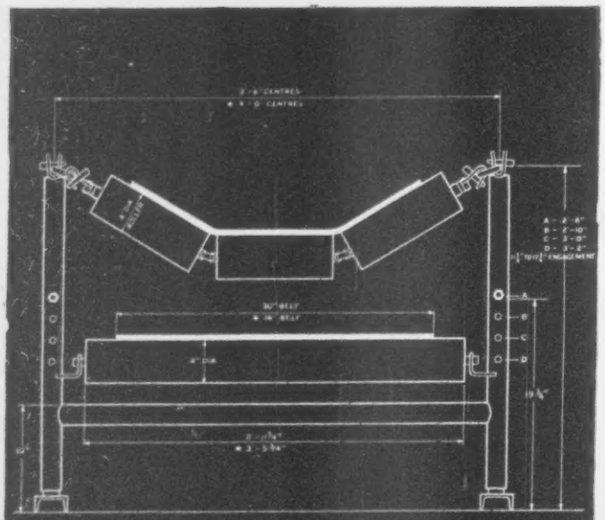

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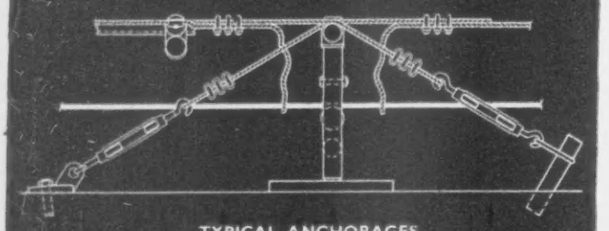

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(Patented)

- *increases belt life*
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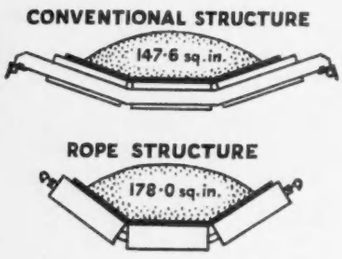
- *increases capacity*
- *almost eliminates spillage*
- *inexpensive*



Greater conveying capacity obtainable by increased troughing under load

The longitudinal members of this conveyor structure consist of $\frac{5}{8}$" dia. steel ropes in tension. The connections at the ends of each troughing idler shaft are hinged. These basic features provide a resilient conveyor which is easy to stack, transport and install — a conveyor in which impact damage to the belt as it passes over the idlers is greatly reduced. The belt is easy to train. The bottom belt is in full view and there need not be any concealed rubbing between belt and structure.

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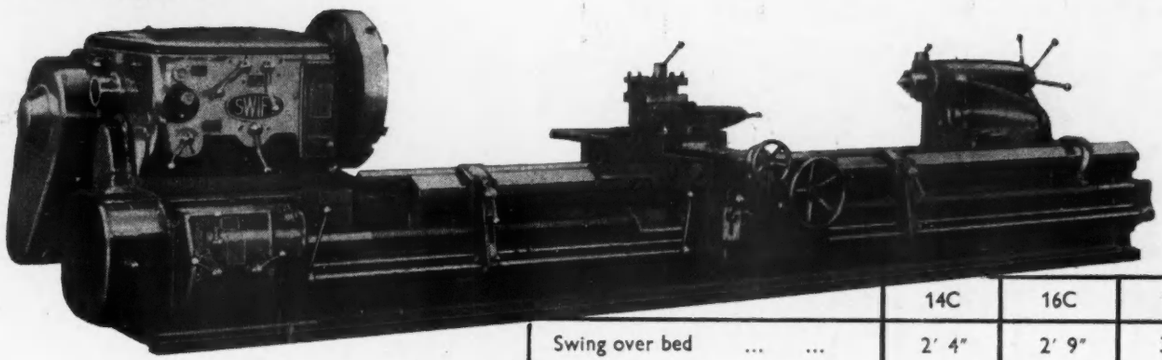
HIGH QUALITY HEAVY DUTY LATHES FOR THE MODERN MACHINE SHOP

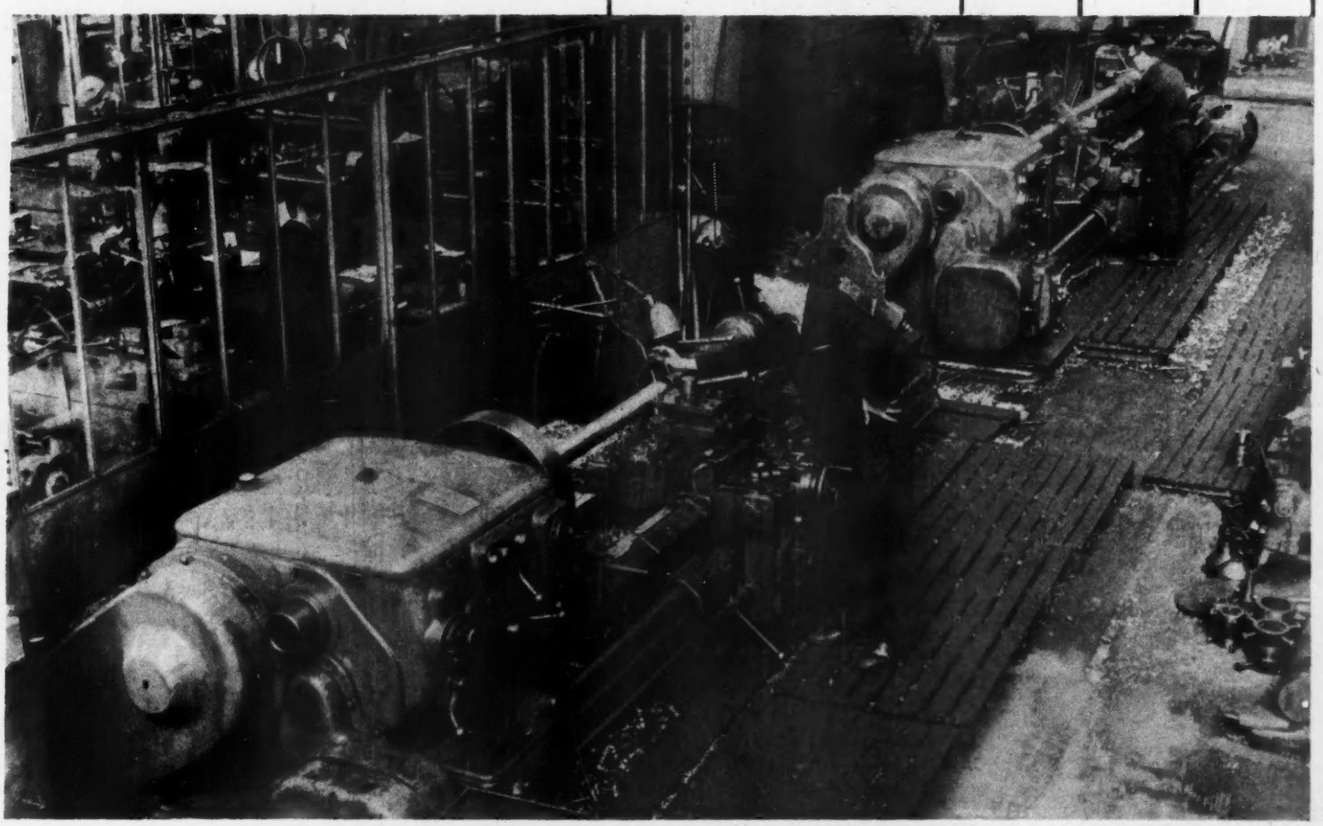


The illustration below shows two Swift "C" type lathes installed in the machine shops at Babcock & Wilcox Ltd., Renfrew. These lathes have adequate power, rigidity, and wide range of spindle speeds to take full advantage of carbide tools and for heavy duty cutting with high speed steel tools. The Swift "C" type lathe is built in three sizes shown opposite.

GEORGE SWIFT & SONS LTD.
HALIFAX . ENGLAND

	14C	16C	19C
Swing over bed	2′ 4″	2′ 9″	3′ 3″
*Length of bed	12′ 6″	15′ 0″	16′ 6″
Min. between centres ...	6′ 3″	8′ 3″	9′ 9″
Swing over saddle	17½″	22½″	28½″
Swing in gap (if required) ...	4′ 0″	4′ 6″	5′ 0″
H.P. recommended for average duty	15	20	25

* Beds can be supplied to any length.



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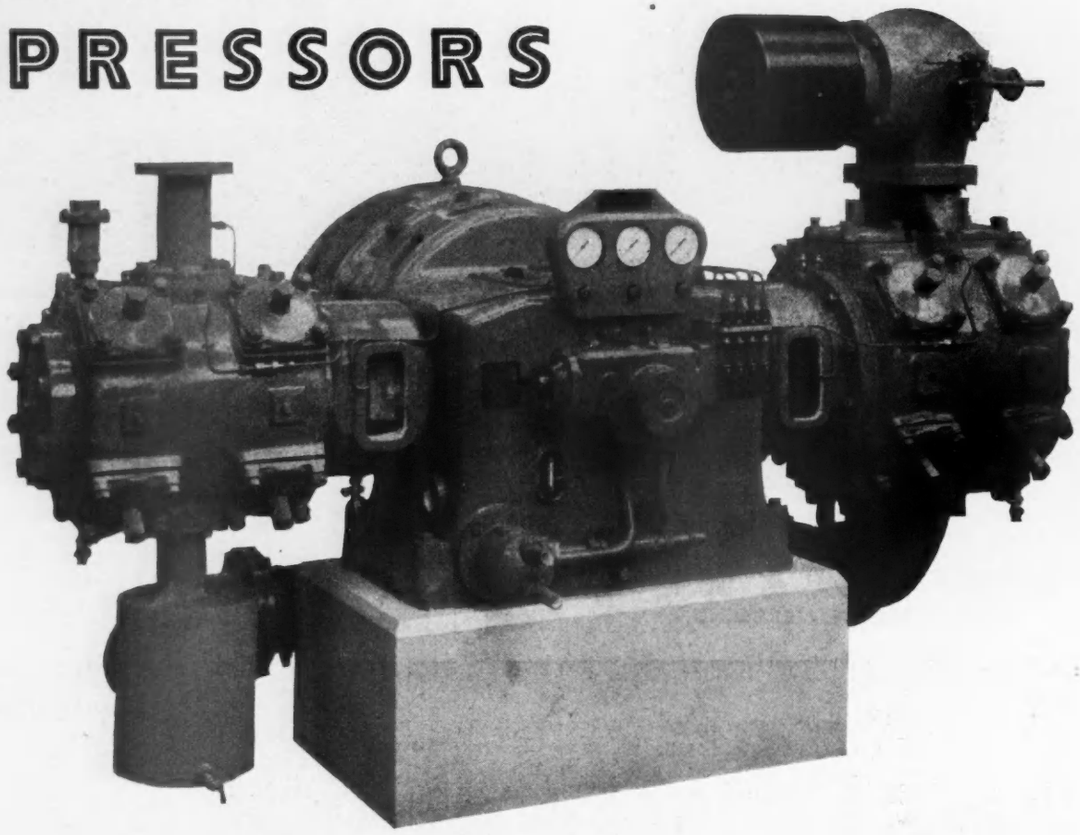
ALLEY

BALANCED OPPOSED COMPRESSORS



The long established high quality of Alley Compressors is combined in these machines with the known advantages of the horizontally-opposed design.

COMPACTNESS: Intercooler lies below motor. Motor is built on.

BALANCE: No horizontal or vertical out-of-balance forces.

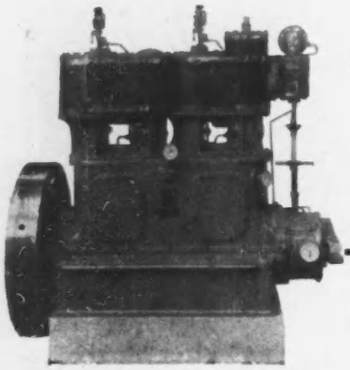
FREEDOM FROM VIBRATION

Can be installed on a minimum foundation—even on an upper floor.

The unit is complete—intercooler and oilcooler incorporated—ready for bolting down.

Range of single and two stage machines up to 10,000 c.f.m.

A corresponding range of VACUUM PUMPS is available with displacements up to 12,000 c.f.m.



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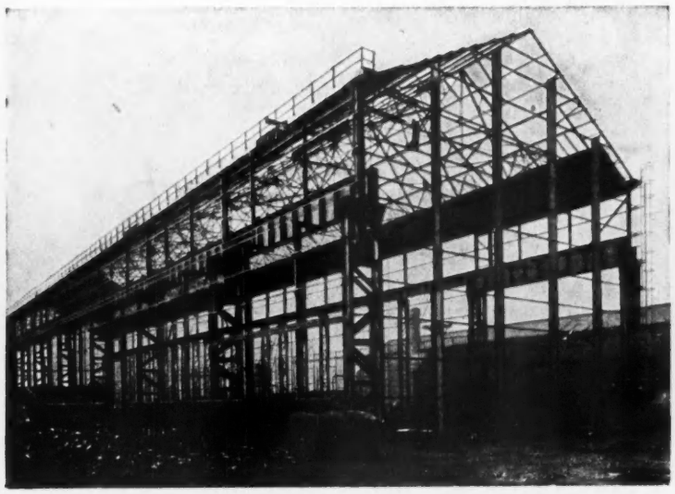

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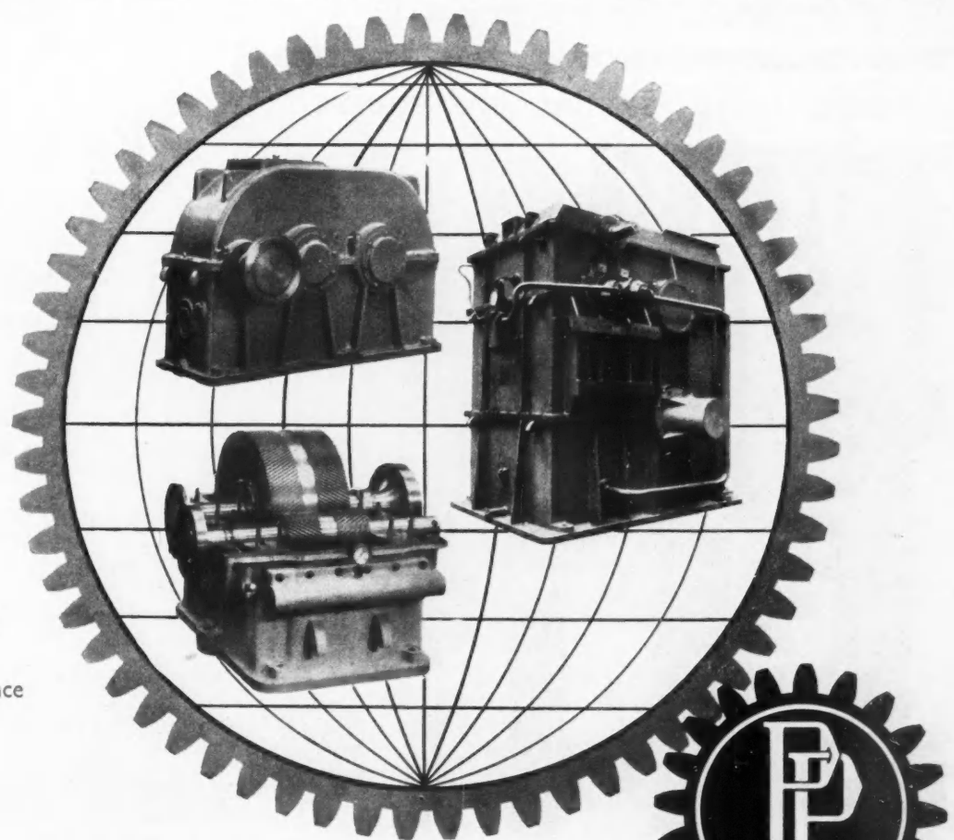

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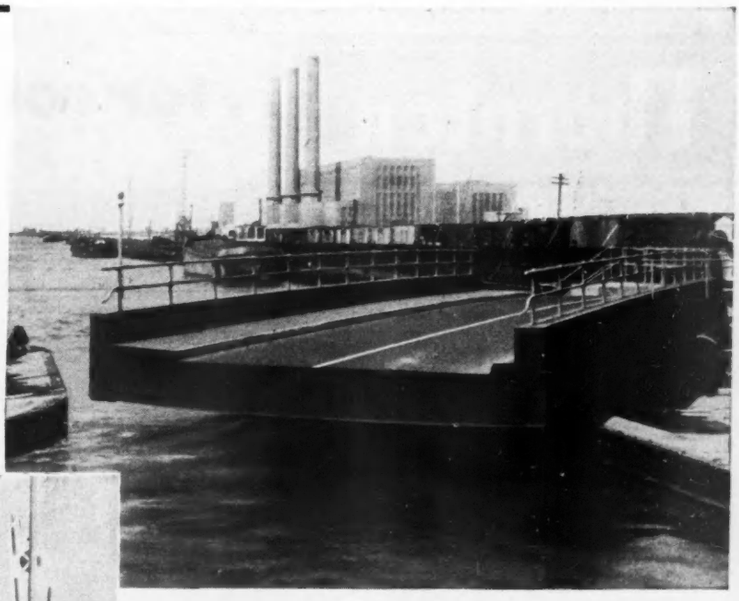

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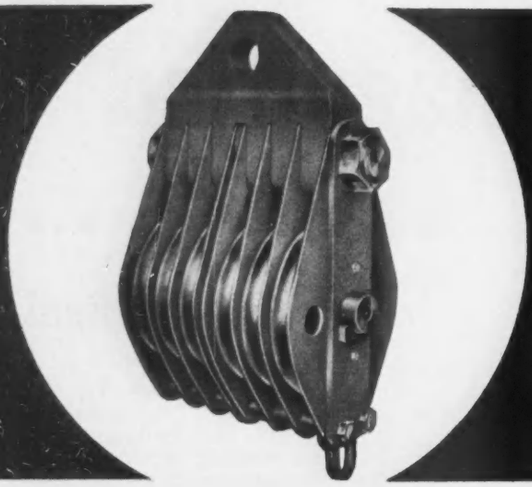

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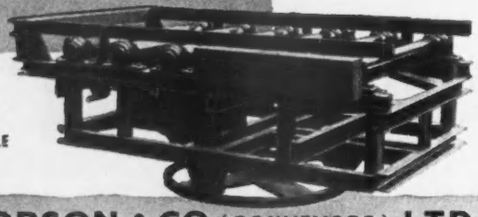

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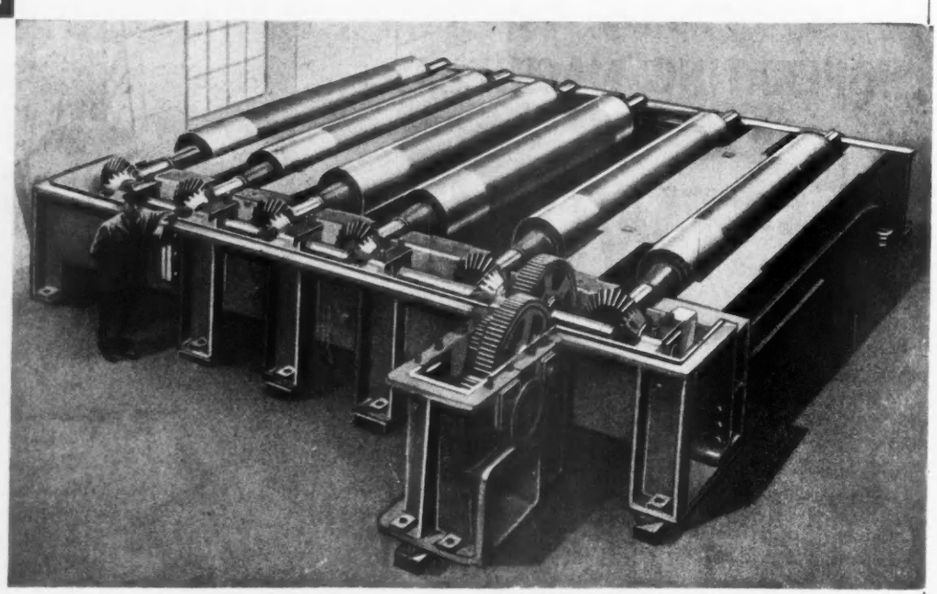

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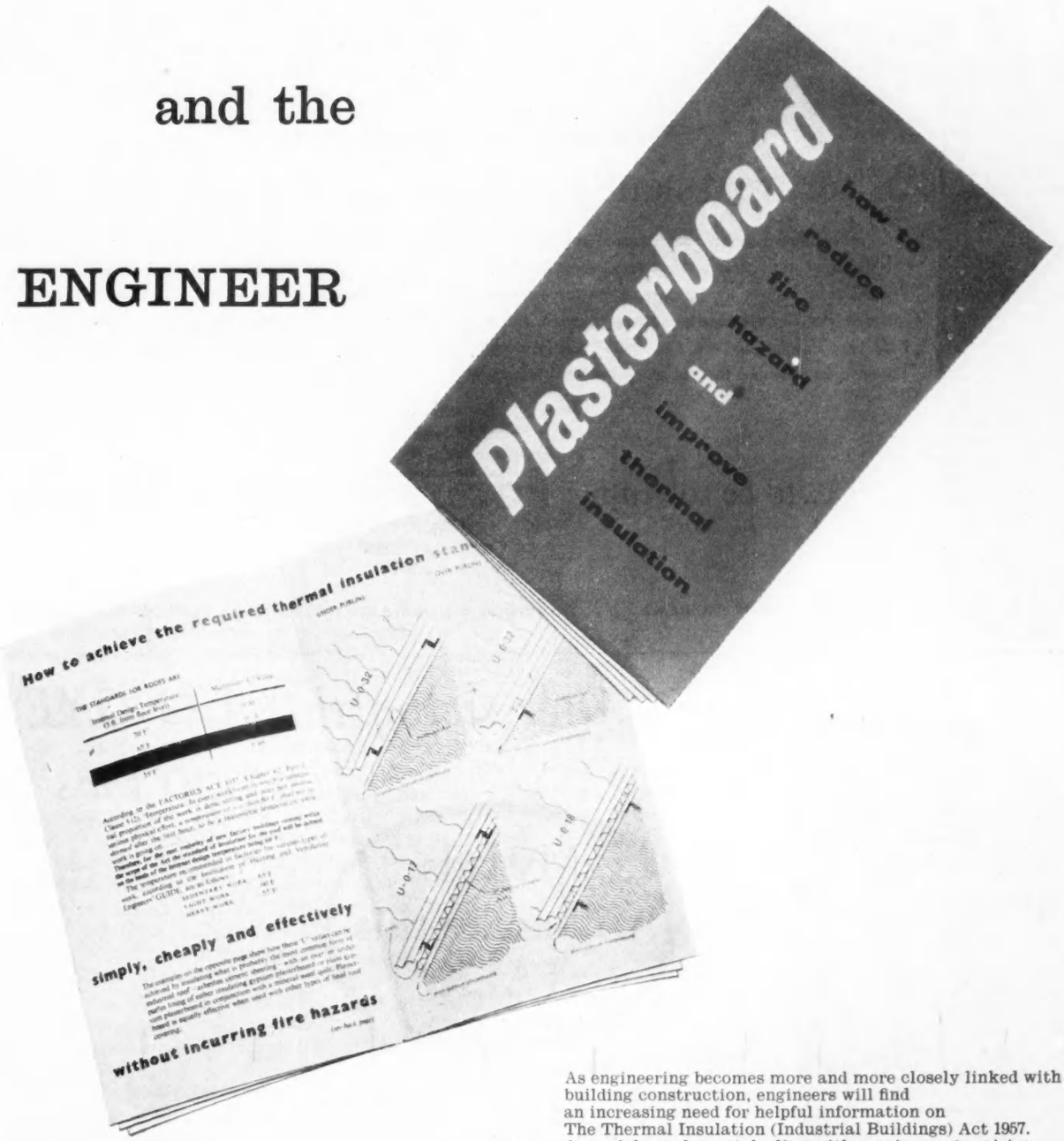
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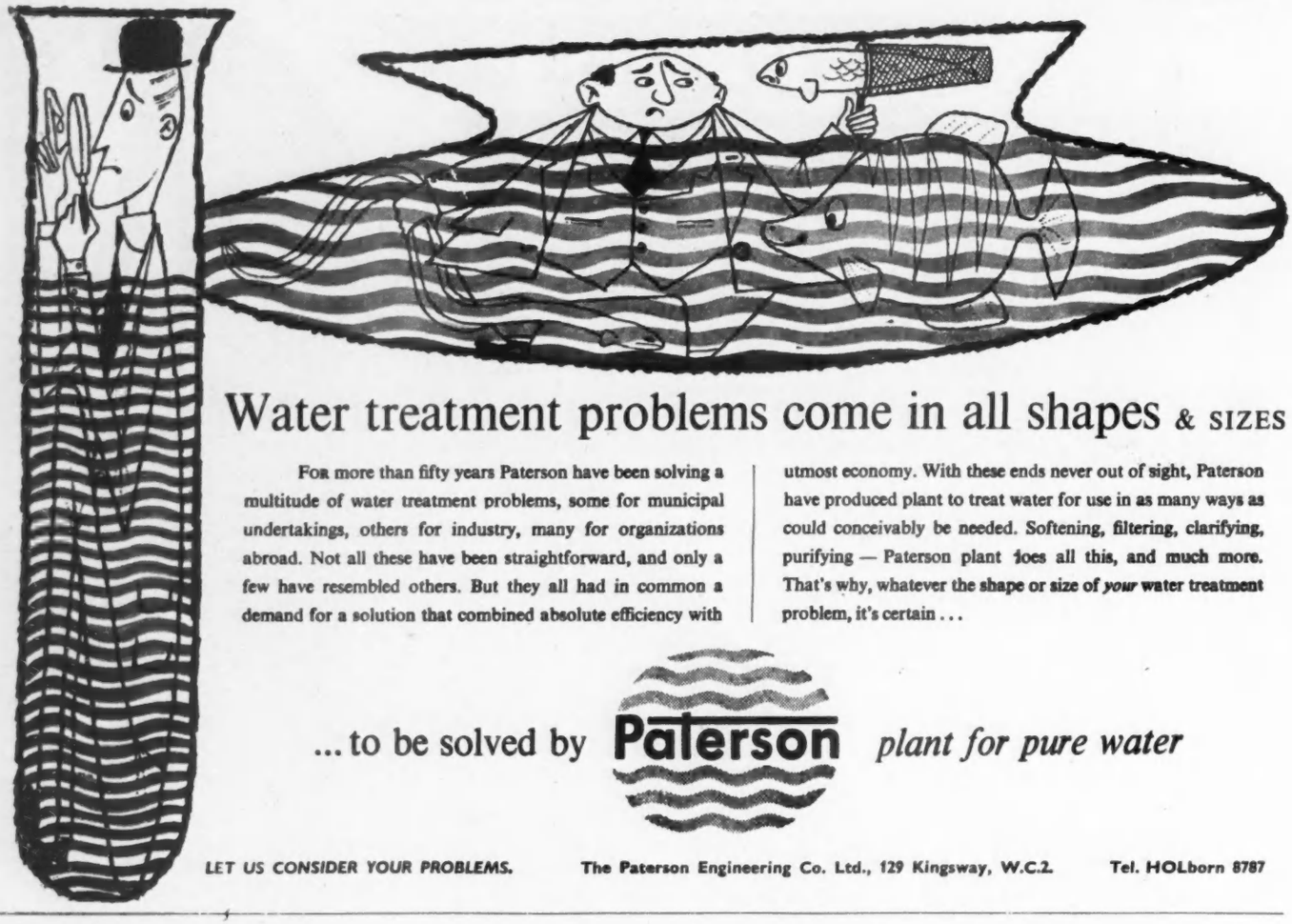

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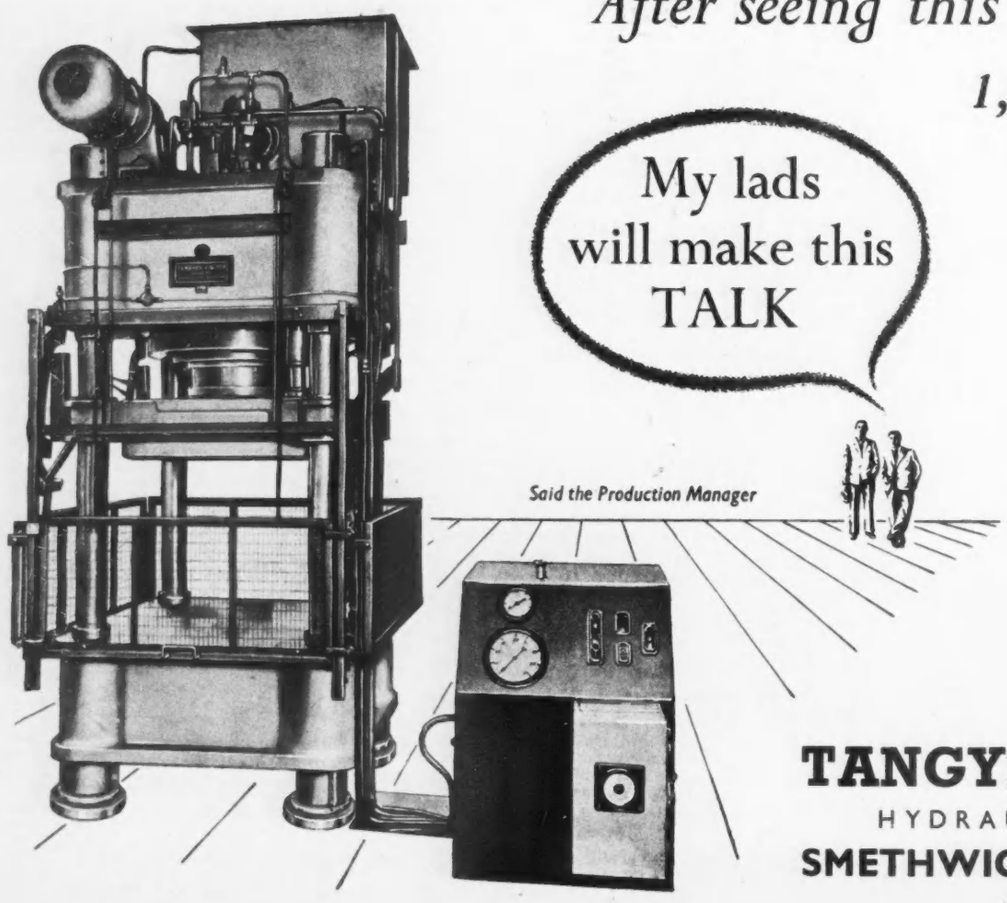

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THE ENGINEER

No. 5378 FEBRUARY 20, 1959 VOL. 207

THE DEFENCE WHITE PAPER—1959

Since 1957 Britain has been concentrating on measures to prevent rather than to wage war—a defence policy framed to cover a period of five years. The Defence White Paper presented to Parliament last week is thus merely a report of the progress made during the past two years in implementing the plan and from the Government's point of view it is very satisfactory. Despite the greatly increased cost of new weapons and equipment and substantial increases in pay and pensions the defence budget for 1959–60, allowing for £12,000,000 to be received from Germany, has been kept at round about the £1500 million level and is only £8,000,000 higher than the revised estimated expenditure for the current year. There is also much cause for satisfaction in the recruiting figures. The figures for all three Services last year suggest that the most important new feature of the defence plan is now likely to be achieved—the abolition of National Service by 1962. Indeed, the six- and nine-year engagements produced 22,000 recruits for the Army in 1958 compared with only 4900 in 1957, with proportionate increases for the other two Services. This has induced the Government to increase the planned strength of the Army from 165,000 to 180,000—a figure which is probably nearer the ceiling originally asked for by the C.I.G.S. The White Paper indicates that there is now better provision for the protection of the colonies and other overseas territories, but leaves us unconvinced that Britain is " continuing to play her part in the collective defence of the free world." Russia has no intention of committing suicide. But she appears to be aiming to dominate the under-developed countries and in the event of a local war overseas, her immense submarine force might well be used in attempts to cut the Atlantic lifeline and so induce N.A.T.O. to call a halt to any extension of hostilities. This is the kind of war in prospect —a war fought almost, if not entirely, at sea and without the H-bomb. Can Great Britain leave to the United States Navy the main responsibility for protecting her trade routes on the wide oceans ?

Mr. Sandys begins his report with a reference to the modernisation of the Fleet, but gives no new information. Two of the four guided missile fleet escort vessels of destroyer type, ordered three or four years ago, are to be laid down in the near future and the surface-to-air " Seaslug " and " Seacat " guided missiles respectively are to provide the Navy's future long-range and short-range anti-aircraft armament. The Westland " Wessex " helicopter is to be the Navy's main anti-submarine aircraft and preparations for constructing Britain's only nuclear submarine—H.M.S. " Dreadnought "—are proceeding. The " Blue Streak " rocket is regarded as the missile best suited to British needs—a wise decision as an alternative to the very costly ballistic rocket submarine. But we are still of the opinion that surface ships partly armed with the 1500-mile solid-fuel " Polaris " will in due course provide a safer and more effective deterrent—and also render this country less liable to bombardment.

The re-equipment of the Army makes satisfactory progress. During 1959 half the Army will have the F.N. rifle and deliveries of the " Stirling " sub-machine-gun will be almost completed. A more advanced version of the " Thunderbird " is being developed. Other new weapons under development include air-transportable anti-tank weapons, tracked vehicles, bridging equipment and short-range nuclear weapons. Apart from glowing accounts of the efficiency of the " Vulcan " and " Victor " bombers, the White Paper gives clear evidence that the carrying capacity of the R.A.F. transport is to be substantially increased. " Britannias " will be in service this year for long-range movement, thus releasing the " Hastings " for the tactical transport role. Long-distance air-freighters, for carrying bulky equipment, are being ordered ; and the number of tactical freighters, suitable for dropping parachutists is also being increased by a military version of the Armstrong-Whitworth " Argosy." For shorter range transport, " Twin Pioneers " are coming into service, to be followed later by Bristol " 192 " helicopters. Finally it is very satisfactory that great importance is now being attached to improving living conditions and providing suitable accommodation. More than 1000 new married quarters were completed during 1958 and it is planned to start on 4000 more during the coming year.

AIR FARE DIFFERENTIALS

International discussions were resumed in Paris on February 16, 1959, in an attempt to resolve the question of the fares to be charged on the jet aircraft now entering airline service. A conference on the same subject held in Nice in the latter part of last year ended in deadlock because the carriers were unable to agree. A minority pressed for higher fares for the jets but the majority was opposed to the idea, on the ground that the jets will be no more expensive to operate than the earlier propeller-driven types and, indeed, that they represent the inevitable next step in technical re-equipment of the airlines which should, in due course, lead to a continuation of those reductions in fares which have made a fundamental contribution to the expansion of air transport since its earliest days. The United Kingdom has strongly supported the case for a fare differential in favour of turbo-props, at least for shorter-haul routes, but it may be that this country will have to give way on this point in the interests of achieving that agreement on fares which is essential to international airline operations.

A jet/turbo-prop fare differential would unquestionably be in the interests of the British tax-payer, of all airlines which have bought turbo-props, of the British (and possibly Russian) aircraft industry, and of Lockheeds in the U.S.A. The British tax-payer is particularly interested because he has invested many millions of pounds in the development of turbo-prop transports and because he owns B.E.A. and B.O.A.C. which are amongst the world's largest turbo-prop operators. A fare differential would probably remain of benefit to all these parties, anyway for

about the next ten years, in spite of the substantial investment which some of them have now also made in jets. This benefit arises because jets could be operated profitably at a higher fare alongside turbo-props, but turbo-props are unlikely to be able to survive for long alongside jets if they have to operate at the same fares. With a differential, an adequate financial return could be obtained from both jet and turbo-prop investments. Without a differential, turbo-prop investments seem likely to give steadily deteriorating returns from now on. For those who have so far pinned their faith mainly on turbo-props, there is unlikely—at least for quite a long time—to be adequate compensation for turbo-prop losses from anything which they can now do to increase the return on such jet investments as they may have also made. It would be impractical, however, and in the long run against the best interests of the air transport industry as a whole, to try to get a fare differential for any restrictionist or protectionist reason. The whole pattern of development during the past forty years—in the march of progress towards progressively cheaper and larger-scale air transport—has been controlled by the evolution of the transport aeroplane, which has itself taken place in the wake of aeronautical research and development undertaken primarily for military purposes. The lowest fare and the best service to the travelling public achievable at any given stage of development, which has resulted from the policy of adopting the most advanced types of aircraft available, has always led to further expansion and progress. There is no reason to believe that it will not continue to do so. In the present state of the art, turbo-props could be developed with operating costs some 10 per cent lower than those of equivalent jets. However, in existing circumstances, where no advanced new long-haul turbo-props which are technically fully contemporary with the new big jets have been ordered by the airlines, it will not be possible to establish in practice that turbo-props have significantly lower seat-mile costs than jets on long-haul routes. It seems necessarily to follow that any demand for the charging of higher fares for jets will be regarded as restrictionist and protectionist by a majority of the long-haul carriers, now heavily committed to jets. On short-haul routes, the turbo-prop is in a somewhat more favourable position. But even in this class of operation, the picture is likely to be influenced by the pattern set on the long hauls and by the fact that the French Sud-Aviation "Caravelle" short-haul jet is an exceptionally economic aircraft of its type. It looks therefore likely to be difficult, even on short hauls, to justify a fare differential in favour of turbo-props on any general basis. Indeed, the more promising way to obtain fare arrangements of this kind will probably be by negotiation on a route-by-route basis between the parallel carriers concerned. Most airlines, during the next few years, will have obsolete piston-engine equipment which they will not be able to sell at attractive prices and which they may therefore be glad to be able to use for lower-fare services. If turbo-props can be used on these services also, they should be in a strong position to exploit their competitive superiority over the piston-engine equipment.

The discussion adds up, at first sight, to a gloomy picture for the short-term future of British aviation which is heavily committed to turbo-props. But the implications of the situation must be faced. Instead of pressing for a general fare differential in favour of turbo-props, which the majority of operators over the world will certainly oppose, a more realistic approach to the problem may be adopted. An attempt may be made to persuade operators who have surplus piston-engine and turbo-prop equipment that it is in their best interests financially to find a means of using this older equipment at lower fares—particularly on the shorter routes—"underneath" normal-fare jet services. Or would jet operators object that such a proposal was, in fact, equivalent to a surcharge on jet travel ?

RESTRICTIVE PRACTICES IN INDUSTRY

There is nothing world-shaking in the report issued during the past week about an inquiry by the National Joint Advisory Council into "Practices Impeding the Full and Efficient Use of Manpower." It is summarised on page 313 of this issue. But though the report is dull and colourless it does serve to dissipate any impression that British industry is riddled through and through with restrictive practices obstinately maintained by trades unions in the mistaken idea that their members benefit from them whoever else may suffer. That picture is so far untrue that sixty-four industries representing perhaps 29 per cent of all those in civilian employment reported to the council that they experienced no problems and forty-two industries, representing perhaps 39 per cent of all those in civilian employment, had machinery available to allow problems to be adequately discussed. Only in industries representing perhaps 7 per cent of all those in civilian employment were restrictive practices having serious consequences and were there no satisfactory means of resolving problems. Prominent amongst those industries is shipbuilding and ship-repairing, which suffers (though the report does not clearly say so) from inter-union rivalries and demarcation disputes.

Our interest lies particularly with the engineering industry. That industry, because of its size and variety must, in itself, we feel, provide a nearly representative sample of conditions in all industries. We can think very easily of many engineering firms whose relations with their employees are so good that no restrictive practice which is not favourable to the general good could possibly survive for long. We can think, too, of other firms which invariably experience grave difficulties whenever new methods of production, new tools and the like are introduced. But as a report to the council agreed by the Engineering and Allied Employers' National Federation and the Confederation of Shipbuilding and Engineering Unions, and published as an Appendix to the council's report, points out, "great changes have taken place in techniques, methods of production, size of labour force involved and size of establishments in the last half century accompanied by an almost incredibly small degree of friction." It is not claimed by these bodies that the machinery for settling difficulties within the engineering industry is perfect. But "it has operated over very many years with a reasonable degree of success," and it is claimed that "its operation at the present time is undoubtedly as effective as it has ever been." The general impression created is, in fact, that the industry feels fully capable of dealing with any problems arising by itself. Interference from outside would not be welcomed.

DESIGN BY CONSULTANT

It has become traditional that the current problems of consulting engineers generally, should be reviewed by the chairman of the Association of Consulting Engineers in his speech at the Association's annual dinner (see page 308). It is not remarkable that emphasis is always given at that function to the consultant's contribution to overseas development, for that contribution is clearly important and praiseworthy. Nevertheless, the volume

of work which consultants have in hand in this country must be many times greater than that overseas, and it seems strange that the work which they do at home should pass virtually unnoticed on these annual occasions. Another, almost perennial, topic which persists when the affairs of consultants are discussed is that of the contractor who offers an " all-in " bid, or a " turn key " bid as it is sometimes called. Mr. Calvert, this year's chairman, was very critical of this procedure in his speech ; in any case, he pointed out, it needed a consultant to make a comparison between such bids, if such comparison could be made at all. He gave the impression, however, that the Association was rather worried by the advantage which the contractor had of being able to advertise his design service, which a consultant could not. The Association may, indeed, initiate some measure such as a public relations service, to allay its fears. However consultants' designs have stood up well to competition of this kind since the war, and have, we believe, grown in favour as against the " all-in " bid over the past few years. It seems to us that the best advertisement which a consultant can offer is the excellence of his designs ; if he consistently turns out first-class work then the " all-in " bid will not bother him. Indeed, it might prove a useful competitive spur for that rare consultant who might tend to err too greatly towards conservatism !

One other matter of general interest was referred to by Mr. Calvert in his speech, namely, that corporate membership of either the " Structurals," " Chemicals " or the Institution of Mining and Metallurgy is to be regarded on an equal footing with corporate membership of one of the three major Institutions, as a technical qualification for membership of the Association of Consulting Engineers. Such a broadening of the original qualifying group does, indeed, seem to be essential if the Association is to be as influential, and as representative of all consulting engineers, as its policies imply. But it seems to us there are still groups of consultants rather outside the general range of subjects which the Association now overtly covers, in particular, consultant naval architects and aeronautical engineers. Ought not membership of the relevant Institution to qualify a man for membership of the Association ? Or are we asking an awkward question ? For deciding upon what societies are and what are not deemed to be qualifying bodies can prove not only a perplexing but also an invidious job.

EDUCATING AGRICULTURAL ENGINEERS

The decision, announced last week by the Minister of Education, to approve the establishment of a National College of Agricultural Engineering is the outcome of more than three years of painstaking discussion. As long ago as the spring of 1955, the president of the Institution of British Agricultural Engineers stressed the importance of adequate training for professional engineers who are anxious to devote their talents and energy to mechanised agriculture. On that occasion he urged that there was a need for a central college providing facilities for students from this country and overseas to study agricultural engineering in all its aspects. Now, as reported on page 269 of our last issue, such a college is to be built in Bedfordshire on a site near the headquarters of the National Institute of Agricultural Engineering. Although the cost of the land and building, estimated at about £250,000, will fall primarily on the Exchequer, the agricultural engineering industry has given an assurance of its willingness to make a substantial contribution in terms of equipment. The industry has also indicated its willingness to support a number of sandwich course students each year. The intention is that the new college shall provide advanced courses leading to a diploma, the full details of which remain to be settled. The National Diploma in Agricultural Engineering, the examinations for which are organised annually by the Institution of British Agricultural Engineers, is coming more and more to to be recognised all over the world as a suitable qualification ; it is one which could usefully be accepted by the new college.

In its announcement about the project, the Ministry of Education has explained that national colleges are established for important industries which have a relatively small demand for specialised advanced education not justifying general provision by local education authorities. The decision to establish this particular college is a welcome one, for, until fairly recently, agricultural engineering has seldom been regarded as a specially valuable branch of technology. To farming communities in many places, there have been many occasions when the idea of a change from traditional peasant customs seemed unpleasant and even dangerous ! But there have always been some pioneers. We are pleased to recall, for example, that just over a hundred years ago, in THE ENGINEER of January 21, 1859, we felt bound to declare that " in no other branch of human industry is more improvement possible or likely of early attainment than in agriculture." We went on to point to " the prospect of an immense field of operations for a new class of professional men, who as agricultural engineers " were likely to achieve considerable dignity and influence. It is satisfactory to realise that that prophecy is at length being fulfilled. The influence of agricultural engineers is daily extending. The more adequate education and training facilities which become available through a National College of Agricultural Engineering can unquestionably prove of great benefit to this country and to the world.

The Engineer—100 Years Ago (FEBRUARY 18, 1859)

" LABOUR-SAVING MACHINERY "

" It would be difficult to specify what further opportunities exist for such triumphs as have already been attained by labour-saving machinery. Invention, perhaps, may never again furnish us with other aids to production as powerful as the rolling-mill for bar iron, the spinning-mule and cotton-loom, or the power-press .... In engineers' tools, a gradual improvement is going on, whereby a greater amount of work is being turned off with a given amount of attendance. There have been, however, but few recent improvements in this class of machinery, a high standard of strength, accuracy, and simplicity having been attained several years ago. In America, where most kinds of machinery are in an advanced condition of improvement, engineers' tools form an exception ; and it is only within a very recent period that the heavy and accurately-fitted English work has been copied by a few only of the leading American tool-makers ; comparatively few upright boring and turning mills have been made, and generally the American engineers' tools have been wanting in strength, accuracy and adaptation. Experience must determine of what further improvement our own tools are capable in these respects.

" When we contrast the present condition and earnings of the British workman with what they were before labour-saving machinery had become so generally introduced, we cannot fail to observe a remarkable improvement, such as affords great encouragement for the further development of such machinery. Just as we reduce human drudgery, so do we increase the means of human comfort and enjoyment."

Experiments on the Compressive Strength of Anhydrite

By W. J. SKINNER, B.Sc.*

No. II—(*Concluded from page 259, February 13*)

Anhydrite is not a material of which many engineers have experience. But much of the investigation described in this article is of more general application. In particular, the author points out that the theory might profitably be applied to concrete. Anhydrite (anhydrous calcium sulphate) is mined at the Billingham Works of Imperial Chemical Industries, Ltd., at an average depth of 800ft. About 20ft of the seam is extracted by the "pillar and stall" system, leaving, in the present workings, pillars 51ft square with intervening roadways 24ft wide; in a considerable area of older workings the pillars are 42ft square with 18ft roadways. The extraction ratio (ratio of stone won to total stone present in the thickness mined) is thus roughly 0·5 and, at a given depth, determines the compressive stress in the pillars. The choice of the ratio used was originally based on empirical mining experience. One of the chief factors determining the amount of stone which can be safely extracted is, obviously, the compressive strength of the pillars. In the interest of conservation of anhydrite reserves experiments were therefore carried out to obtain an estimate of the pillar compressive strength. A solution of this problem was obtained by the use of the theory of statistics of extreme values. The experiments and application of the results are therefore described in some detail since, although the statistical aspect of many fracture phenomena is now widely recognised, very few examples of application to practical problems are to be found in the literature.

Normal Distribution of Unit Size Strengths

On the basis of a normal distribution of 1in specimen strengths, as each test of a 2in specimen is equivalent to determining the weakest among eight 1in specimens, each test of a 4in specimen is equivalent to determining the weakest among sixty-four 1in specimens, and so on, the values of n to be inserted in equation (7) above for the 2in, 4in and 10in specimens are 8, 64 and 1000 respectively. For mine pillars having a slenderness ratio of 0·5 the value of n for a 42ft pillar would be $1·3\times10^8$ and for a 51ft pillar $2·3\times10^8$. Table IV compares the calculated and observed strengths and standard deviations.

Table IV—*Calculated and Observed Strength Values*

(0·5 slenderness ratio—normal distribution of 1in specimen strength)

Specimen side length	n	Compressive strength (tons/ft²)		Standard deviation (tons/ft²)	
		Observed	Calculated	Observed	Calculated
1in	1	2090	—	296	—
2in	8	1630	1720	166	186
4in	64	1560	1440	132	132
10in	1000	1080	1170	172	102
42ft	$1·3\times10^8$	—	420	—	62
51ft	$2·3\times10^8$	—	390	—	61

The results may also be expressed graphically as shown in Fig. 10. Here, the individual forty-four results for the 1in specimens are plotted against the cumulative probability of failure with a straight line drawn to correspond with their mean strength and standard deviation. Theoretically, the observed mean strength values for the larger specimens should also lie on this line. Thus, for example, the observed strength of the 10in specimens should represent the stress which one in a thousand 1in specimens will just not withstand; in other words, the probability of failure of 1in specimens subjected to this stress is 0·001. Fig. 10 shows that the hypothesis that the 1in specimen strengths are normally distributed is sufficiently accurate for the representation of results over the range investigated.

Weibull Distribution of Unit Size Strengths

The unit size for which the strengths approximately follow Weibull's distribution will not necessarily be the same as that for the normal distriubtion, but it is unnecessary to know the unit size in this case since the strength-size relation can be expressed in terms of actual specimen volume as in equation (6). Fig. 11 shows the logarithm of the observed strengths plotted against the logarithm of the specimen volume; for convenience, the specimen volume is again expressed in terms of the 1in specimen as the unit volume, thus making the value of the constant K in equation (6) equal to the logarithm of the 1in specimen mean strength. The relationship between the two variables in Fig. 11 is reasonably linear and is best expressed by the equation

$$\log_{10} S = 3·30 - 0·079 \log_{10} n$$

or, in terms of specimen volume,

$$\log_{10} S = 3·30 - 0·079 \log_{10} 2V \quad . \quad . \quad . \quad (8)$$

where V is the specimen volume in in³. The constant 0·079 is the numerical value of $1/\beta$. Table V compares the calculated and observed strengths and standard deviations.

Table V—*Calculated and Observed Strength Values*

(0·5 slenderness ratio—Weibull distribution)

Specimen side length	n	Compressive strength (tons/ft²)		Standard deviation (tons/ft²)	
		Observed	Calculated	Observed	Calculated
1in	1	2090	2020	296	242
2in	8	1630	1710	166	205
4in	64	1560	1450	132	175
10in	1000	1080	1160	172	140
42ft	$1·3\times10^8$	—	460	—	55
51ft	$2·3\times10^8$	—	440	—	53

Over the experimental range the calculated strengths are almost identical with those given in Table IV. The calculated pillar-sized specimen strengths are slightly higher.

Discussion of the Two Methods of Calculation

Theoretically, the strength of a specimen should not approach zero until the specimen size becomes indefinitely great. The use of equation (7) is unsatisfactory in this respect, since it requires the specimen strength to become zero at 7·1 standard deviations below the unit size strength. This occurs at a value of n of about 10^{12}, which corresponds to a pillar having a side length of about 830ft, and still larger sizes would have negative strengths according to equation (7). This unsatisfactory feature results from assuming a normal distribution of unit size strengths, for about one billionth of the area under a normal distribution curve whose mean is +7·1 standard deviations lies on the negative side of zero. There is about a 1 in 10^{12} chance that a randomly chosen member of the population, whose distribution the curve represents, will have a negative value.

The Weibull distribution is more satisfactory in this respect, since the probability density function tends towards zero as the strength approaches zero.

In view of the premature fall to zero of strength calculated from equation (7), the strengths calculated from it for pillar-sized specimens will be slightly low. The slightly higher figures calculated from the Weibull distribution and given in Table V were, therefore, used as a basis for pillar strength calculations.

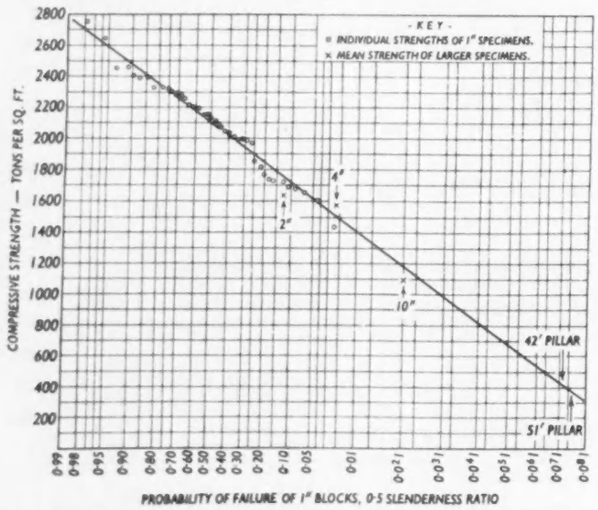

Fig. 10—Probability of failure of 1in specimens versus compressive strength

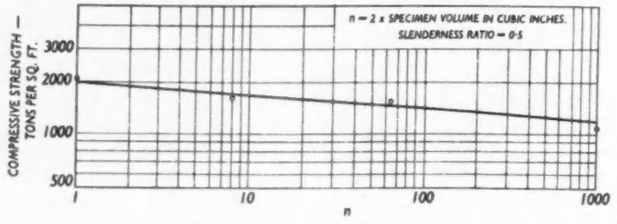

Fig. 11—Log S versus Log n

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Effect of Slenderness Ratio

(*a*) *General.*—The average slenderness ratios of the two main sizes of pillar in the mine lie close to the values 0·4 and 0·5. The majority of experiments on the effect of this factor were therefore carried out over the range 0·3 to 0·6, which covered the pillar shapes likely to be of interest under present mining conditions. One series of tests was, however, extended to much higher slenderness ratios in an attempt to throw further light on the mechanism of the shape factor. In most cases anhydrite samples of uniform texture were used to avoid the confusing effect of quality variation; tests on the largest possible specimens of run-of-mine

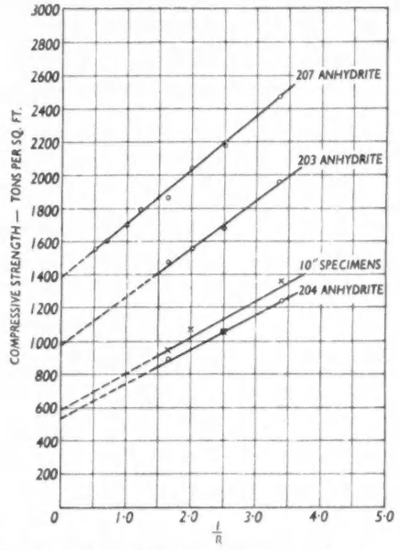

Fig. 12—Compressive strength versus reciprocal of slenderness ratio

stone were included, however, as the nearest experimental approximation to actual pillars. To obtain some indication of the effect of the anisotropy resulting from the bedding, a few specimens of the sample (anhydrite 207) used in the most extensive series were also tested with the bedding normal to the compression faces.

(*b*) *Results.*—The results obtained are summarised in Table VI. Fig. 12 shows that, as has been found in the case of some other materials (e.g. Bauschinger's tests on sandstone[18]), the mean strength S of a given sample is inversely related to the specimen slenderness ratio R as follows:

$$S = A + \frac{B}{R}$$

where A and B are parameters with values appropriate to that sample and having the dimensions of stress per unit area. When the dispersion of the results is low, i.e. when the anhydrite quality is uniform, this equation is followed with considerable accuracy.

Inspection of Fig. 12 also indicates a tendency for the values of A and B to decrease together. General considerations, outlined below, show that this is to be expected and indicate that when the value of one parameter becomes zero the value of the other will also be zero. Fig. 13, where B is plotted against A/B, shows that the two parameters are, in fact, related by the equation $B^2 = a.A$. The value of the constant a best fitting the results is 82·5 tons per square foot. The equation relating strength and slenderness ratio can therefore be rewritten in terms of only one unknown parameter, i.e.

$$S \text{ (tons per square foot)} = \frac{B^2}{82{\cdot}5} + \frac{B}{R} = 0{\cdot}0121B^2 + \frac{B}{R} \quad \ldots\ldots (9)$$

The specimens of 207 anhydrite in which the bedding was oriented normally to the compression faces had appreciably lower strengths than when tested in the normal way and the results tended to be more variable. It is also of interest that the relation between the parameters A and B apparently still holds for this method of testing.

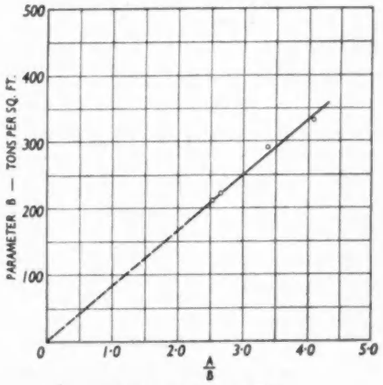

Fig. 13—B versus A/B

Table VI—*Effect of Slenderness Ratio*

Sample code No.	Specimen side length (inches)	Slenderness ratio	No. of specimens tested	Mean compressive strength (tons/ft²)	Range of observed strengths (tons/ft²)	Standard deviation (tons/ft²)
207	1	0·3	8	2470	2430–2510	36
		0·4	4	2180	2120–2220	43
		0·5	4	2040	2010–2060	22
		0·6	2	1860	1850–1870	14
		0·8	4	1790	1640–1900	130
		1·0	4	1700	1650–1750	52
		1·43	4	1600	1560–1620	27
		1·89	4	1540	1520–1550	19
207*	1	0·3	5	2100	1910–2210	119
		0·6	4	1520	1350–1640	124
203	1	0·3	4	1950	1930–1970	18
		0·4	4	1660	1600–1680	36
		0·5	4	1550	1490–1600	48
		0·6	4	1490	1450–1510	30
204	½	0·3	6	1240	1090–1340	86
		0·4	6	1050	980–1080	37
		0·6	9	890	780–960	54
Run-of-mine stone	10	0·3	3	1350	1290–1440	69
		0·4	4	1060	860–1320	199
		0·5	4	1080	930–1290	172
		0·6	3	950	780–1070	128

* Bedding normal to specimen compression faces.

Discussion

It does not seem to be possible to formulate a realistic stress system which explains the observed simple relation between compressive strength and slenderness ratio. Some general comments can, however, be made.

The vertical splitting sometimes observed in compression tests is presumably due to lateral tension. As the tensile strength of bedded anhydrite is lower in a direction normal to the bedding than parallel to it, the above observations on the effect of bedding orientation also suggest that lateral tensile forces may play an important part in causing failure of anhydrite in compression. The same observations indicate that it is unlikely that fracture is due to shear forces, as an explanation on this basis would require a reversal of the effect of bedding orientation. The fact that the reciprocal strength-slenderness ratio relationship has been observed with more nearly isotropic materials suggests, however, that this form of relation may not result from strength anisotropy. It should also be noted that part of the change in strength accompanying slenderness ratio variations may be due to size effects. In the case of the 207 anhydrite, about 20 per cent of the total strength change between slenderness ratios of 0·3 and 1·89 can be attributed to the size effect if it is assumed that the flaw density and size distribution remain constant.

The variation in the values of A and B from sample to sample is due to two factors, namely, crystal size and specimen cross-sectional area (side length). The values decrease with increasing crystal size, as illustrated by the results for anhydrites 207 and 203. The following considerations show that, when the crystal size is constant, the values must decrease with increasing specimen cross-sectional area.

Since the strength at a given value of R decreases with increasing specimen size, it is apparent that the value of A will decrease with increasing side length. The value of B must also decrease for otherwise before an indefinitely large side length was reached the S versus $1/R$ line would intercept the abscissa and negative strengths would have to be attributed to specimens with large slenderness ratios. In fact, the strength of specimens of any slenderness ratio in the region ABC of the curve in Fig. 1, will not approach zero until the side length becomes indefinitely large, so that in the limit the S versus $1/R$ line will become the abscissa. The values of A and B must therefore decrease and approach zero together.

This parallelism of the effects of crystal and specimen sizes is not surprising, since the size effect is merely the result of the increase in probability that larger crystals will be present when the specimen size increases. In general, it may be concluded (for brittle crystalline materials) that under conditions where the size effect is small the slenderness ratio effect (value of B) will also be small. In agreement with this, it is found that in plaster specimens, which show no appreciable size effect, the compressive strength is virtually independent of slenderness ratio.

Although the compressive strength of an infinitely long specimen will actually be zero, the value of the parameter A may be regarded as the true free compressive strength of the sample and cross section to which it refers, i.e. as the compressive strength unmasked by effects of geometry. It does not appear to be possible at present to attach any such physical meaning to the parameter B. Similarly, the physical meaning of the constant a relating A and B is not known, although its constancy for widely divergent anhydrite types and specimen sizes suggests that it is derived from fundamental constants.

Numerical Example

The mean strength of pillar-sized specimens was readily calculated from the foregoing

results. The case of 42ft square by 20ft high pillars may be taken as an example.

The average strength of specimens with a side length of 42ft and a slenderness ratio of 0·5 is estimated to be 460 tons per square foot (Table VI). The value of the constant B in the slenderness ratio equation for this side length may then be calculated from

$$460=0\cdot0121B^2+\frac{B}{0\cdot5}$$

giving

$$B=129 \text{ tons per square foot.}$$

The mean strength S of pillars with this side length and any slenderness ratio R is thus given by

$$S=201+\frac{129}{R}.$$

When the pillar height is 20ft the mean compressive strength is therefore

$$201+129\cdot\frac{42}{20}=472 \text{ say } 470 \text{ tons per square foot.}$$

GENERAL DISCUSSION

(*a*) *Size of Flaws in Anhydrite.*—It is of interest to estimate the sizes of the flaws which, according to Griffith's theory, would give some of the observed compressive strengths. This requires values of s_0, E and T for substitution in equation (1). The specific surface energy of rocks is usually of the order of 10^3 ergs per square centimetre. The ultrasonic pulse velocity in several types of anhydrite is $4\cdot4\times10^5$ cm per second ; if Poisson's ratio is assumed to be 0·2, Young's modulus is about 5×10^{11} dynes per square centimetre. The tensile strength can be estimated for the cross section and sample in question from the value of the parameter A, for, according to Griffith[9] the tensile strength of a brittle material is one-eighth of its compressive strength. For example, the estimated tensile strength of 1in square specimens of 207 anhydrite is about 1 ton per square inch in reasonable agreement with values of about $\frac{1}{4}$ ton per square inch observed in tensile tests (parallel to the bedding) on similar types of stone. If the flaws are assumed to be actual cracks, substitution of the approximate values in equation (1) gives a crack length of approximately 300μ for a 1in square section of 207 anhydrite and 600μ for a $\frac{1}{2}$in square section of 204 anhydrite. These figures are necessarily very approximate, but it is of interest that they are commensurate with the diameter of the largest crystal that would be present in specimens of the size to which they refer. The crack length required to give strengths of the order calculated for pillars would be about 0·4cm.

(*b*) *Nature of the Flaws in Anhydrite.*—Generally, a flaw may be regarded as any type of discontinuity or inclusion which magnifies locally the applied stress. A possible interpretation of the relation between flaw and crystal size in brittle crystalline materials is that the flaws are cleavage cracks. The stress conditions arising from this type of crack have been investigated by Elliott,[17] who found that it gives the same fracture condition, with only slightly different values of the numerical factors, as Griffith's elliptical crack. It is not known whether the critical step in producing fracture is the initiation of crack propagation within a crystal or propagation across the crystal boundary into the next. In the former case, if the flaws are cleavage cracks, cleavages must exist in the specimen before stressing ; in the latter case, the flaws may be partly or wholly engendered during stress application. As anhydrite is a readily cleavable mineral (perfect (010) and distinct (100) cleavages) it seems possible that the flaws in it are cleavage cracks ; the explanation of pre-existing cleavages, if necessary, would present no difficulty since these could readily arise from local stresses resulting from recrystallisation, hydration or dehydration of the parent deposit during its geological history.

The possibility that the flaws are produced by stress release when the anhydrite is mined cannot be entirely excluded. In this event there would be no size effect in the *in situ* material and the pillar strengths would be considerably greater than those calculated above. It would manifestly be unwise to make this assumption for practical purposes.

During the tests on run-of-mine stone it was observed that the strength characteristics of specimens containing gypsum porphyroblasts closely resembled those of specimens with a similar anhydrite crystal texture, but free from porphyroblasts. The porphyroblasts do not, therefore, appear to act as large and sparse flaws, for otherwise the strength of anhydrite containing them would be much lower and much more variable than that of gypsum-free anhydrite. This failure to act as flaws is possibly due to gypsum being far too weak to transmit the relatively intense stress necessary to initiate a crack in the surrounding anhydrite matrix. The tendency noted in a few tests for strength to decrease slightly with increasing gypsum content may indicate, however, that the porphyroblasts can act as holes in the matrix, thus leading to a small stress enhancement in the surrounding areas.

Also, during these tests, a careful record was kept of the presence or otherwise of macroscopic cracks in the specimens. No correlation was found between strength and the severity of these macroscopic flaws, extensively cracked specimens giving strengths higher than the mean for the particular sample of stone as frequently as below the mean in the same manner as the apparently uncracked specimens.

(*c*) *Limitations of the Chain Model.*—Although the simple chain model accounts fairly satisfactorily for the size effect in specimens of constant slenderness ratio, there is little doubt that it presents an oversimplified picture, particularly when changes of slenderness ratio are involved. There are variations of stress within a compressed specimen and the stress distribution probably changes with slenderness ratio. The weakest link hypothesis is obviously only tenable, in its simplest form, so long as all of the flaws are subjected to the same stress as are the links in a tensioned chain. Also, a more satisfactory model would perhaps represent the flaws grouped as a combination of series and parallel units rather than as a single series. In the case of anhydrite and similar materials the situation is further complicated by the anisotropy, for, apart from possible effects on stress distribution, if the orientation of the maximum stress changes with slenderness ratio the effective flaw density and size distribution will also vary. However, it would appear that, in the present state of knowledge in this field, no practical advantage would be gained by attempting to use a more refined model.

(*d*) *Other Applications.*—The application of the statistical theory to other problems of brittle fracture would appear to be worthwhile. A field of great practical importance is that of building materials and the case most worthy of study is, perhaps, that of concrete in which the size effect and accompanying change in strength dispersion were demonstrated over twenty years ago. Attention has recently been refocused on the change of standard deviation of strength with specimen size.[20] The establishment of a satisfactory statistical model may throw further light on the mode of failure of concrete in compression and lead to some modification of present methods of design.

APPENDIX

THE STATISTICS OF EXTREME VALUES AND APPLICATION TO THE CASES CONSIDERED‡

(1) Basic Equations

Suppose that the underlying distribution of a variable x, from whose population samples are to be drawn at random, is given by the continuous probability density function $f(x)$. The associated cumulative distribution function $F(x)$ is then given, in the general case where x may have unlimited positive and negative values, by

$$F(x)=\int_{-\infty}^{x}f(x)dx \quad . \quad . \quad . \quad . \quad (1a)$$

i.e. $F(x)$ represents the probability that the value of a single member lies between $-\infty$ and x.

(*a*) *Largest Values.*—It follows from above that the probability that the values of n individuals selected at random all lie within $-\infty$ and x is $F^n(x)$, i.e. this is the probability for x to be the largest value among the n independent selections. The distribution of the largest values in samples of size n is given by the derivative of $F^n(x)$, which is the probability density function.

$$g_n(x)=\frac{d}{dx}[F^n(x)]=nf(x)[F(x)]^{n-1} \quad . \quad (2a)$$

The last equation enables graphs to be drawn of $g_n(x)$ for a given $f(x)$ from which the mode (most probable value) of the largest value of x in samples of size n can be determined. Alternatively, the mode may be found by solving the equation

$$g_n'(x)=0.$$

Now from (2*a*)

$$g_n'(x)=nf'(x)[F(x)]^{n-1}+n(n-1)f^2(x)[F(x)]^{n-2}=0$$

when $g_n(x)$ is at a maximum. Hence, if a solution exists the mode of x, x_n^*, will be given by

$$f^2(x_n^*)(n-1)=-f'(x_n^*)F(x_n^*) \quad . \quad . \quad (3a)$$

The above equations suffice for the determination of the mode of x and for a general description of the distribution of the largest values in samples of size n drawn from a parent population $f(x)$, but are inadequate for a quantitative study of the distribution of the largest values, particularly for large values of n. For the latter purpose it is convenient to introduce a new random variable defined as

$$\varepsilon=n[1-F(x)] \quad . \quad . \quad . \quad . \quad (4a)$$

In terms of this variable (2*a*) becomes

$$h_n(\varepsilon)=\left(1-\frac{\varepsilon}{n}\right)^{n-1} \quad . \quad . \quad . \quad . \quad (5a)$$

where $h_n(\varepsilon)$ is the probability density function of ε.

The probability density function $h(\varepsilon)$ for very large values of n is conveniently given by

$$h(\varepsilon)=\lim_{n\to\infty} h_n(\varepsilon)=e^{-\varepsilon} \quad . \quad . \quad . \quad . \quad (6a)$$

‡ Useful accounts of the theory of the statistics of extreme values with applications to a variety of problems have been given by Gumbell[15] and Epstein.[21]

Using (4*a*) and (6*a*) the distribution of the largest values in large samples can now be completely specified.

(*b*) *Smallest Values.*—Similar argument to the above shows that the probability that x is the smallest value in a sample of size n is $1-[1-F(x)]^n$ and the derivative of this gives $g_n(x)$, the distribution of the smallest values

$$g_n(x)=nf(x)[1-F(x)]^{n-1} \quad . \quad . \quad (7a)$$

Again, the value of the mode x_n^* is given by the solution of $g_n'(x)=0$, which is

$$f^2(x_n^*)(n-1)=f'(x_n^*)[1-F(x_n^*)] \quad . \quad (8a)$$

As before, for quantitative examination of the distribution of smallest values it is convenient to introduce a new random variable, defined in this case as

$$\varepsilon=nF(x) \; . \; . \; . \; . \; . \; . \quad (9a)$$

In terms of this variable (7*a*) then becomes

$$h_n(\varepsilon)=\left(1-\frac{\varepsilon}{n}\right)^{n-1} \quad . \; . \; . \; . \quad (10a)$$

where $h_n(\varepsilon)$ is the probability density function of ε. Again, for very large values of n this becomes

$$h(\varepsilon)=e^{-\varepsilon} \; . \; . \; . \; . \; . \; . \quad (11a)$$

(2) Applications

(*a*) *Laplacian Distribution.*—If the probability density function of flaw sizes is $f(x)=\lambda e^{-\lambda x}$, since the minimum possible flaw size is zero the cumulative distribution function is

$$F(x)=\int_0^x \lambda \, . \, e^{-\lambda x}dx=1-e^{-\lambda x}.$$

Also, $f'(x)=-\lambda^2 e^{-\lambda x}$. Substituting these values for $f(x)$, $F(x)$ and $f'(x)$ in equation (3*a*) to find the mode of the largest value of x

$$\lambda^2 e^{-2\lambda x_n^*}(n-1)=\lambda^2 e^{-\lambda x_n^*}(1-e^{-\lambda x_n^*})$$
$$ne^{-\lambda x_n^*}=1$$

or

$$x_n^*=\frac{\log_e n}{\lambda} \quad . \; . \; . \; . \quad (12a)$$

The exact distribution, $g_n(x)$ of the largest values in samples of size n is given by

$$g_n(x)=n\lambda e^{-\lambda x}(1-e^{-\lambda x})^{n-1}$$

but this is cumbersome to use, except for small values of n. An approximation to the distribution of the largest values when the sample size is large is obtained by introducing the random variable ε, where

$$\varepsilon=n[1-F(x)]=ne^{-\lambda x}.$$

Taking logs and rearranging,

$$x=\frac{\log_e n}{\lambda}-\frac{\log_e \varepsilon}{\lambda} \quad . \; . \; . \quad (13a)$$

where ε is distributed with the probability density function

$$h(\varepsilon)=e^{-\varepsilon}, \; \varepsilon>0.$$

If $\eta=\log_e \varepsilon$, the approximate distribution of x is

$$x=\frac{\log_e n}{\lambda}-\frac{\eta}{\lambda} \; . \; . \; . \; . \quad (14a)$$

where η is distributed as $e^{\eta}.e^{-e^{\eta}}$, $-\infty<\eta<\infty$.

It may be noted that (14*a*) also gives $\dfrac{\log_e n}{\lambda}$ as the mode of x because the most probable value of η is zero, since

$$\frac{d[h(\eta)]}{d\eta}=\frac{d}{d\eta}e^{\eta} \, . \, e^{-e^{\eta}}=e^{\eta} \, . \, e^{-e^{\eta}}-e^{2\eta} \, . \, e^{-e^{\eta}}=0$$

for maximum $h(\eta)$.
Therefore

$$e^{\eta}=1, \text{ i.e. } \eta=0 \text{ for maximum } h(\eta).$$

Since for any value x of the maximum flaw size, the corresponding strength is $S=kx^{-\frac{1}{2}}$, the expected distribution of strength may be readily obtained. To illustrate the form of the strength distribution curve expected from the above theory and to show the way in which the mode of the strength values decreases with increasing number of flaws, Fig. 14 has been drawn from arbitrarily selected values of the constants k and λ. It should be noted that the results have not been normalised so as to give the same area under each curve, i.e. although the curves give the true relative strength frequencies for a given value of n, the relative frequencies of a given strength for different values of n cannot be directly compared. The slight skewing of the curves towards low strength values should also be noted, as a result of which the mean value and mode do not coincide. Provided n is large, however, the mean and mode may be taken as identical for practical purposes. Thus, the mean value of x for a given n may be calculated from equation (14*a*), since here the random components of x are a function of the random variable η only. The mean value, $\bar{\eta}$ of η is given by

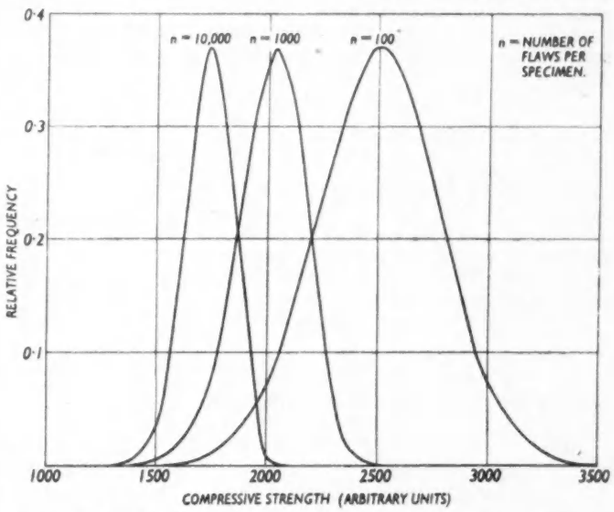

Fig. 14—Theoretical distribution of strengths for Laplacian distribution of flaw sizes

$$\bar{\eta}=\int_{-\infty}^{\infty} \eta . \, e^{\eta} \, . \, e^{-e^{\eta}} \, . \, d_{\eta}.$$

Putting $t=e^{\eta}$

$$\bar{\eta}=\int_0^{\infty} \log_e t \, . \, e^{-t}dt=-0{\cdot}577.$$

Hence, the mean value of x is

$$\bar{x}=\frac{\log_e n}{\lambda}+\frac{0{\cdot}577}{\lambda}.$$

Provided n is large, the second term on the right-hand side of this equation may be neglected and the mean and mode become identical.

The curves in Fig. 14 also show that the range of strength values to be expected as a result of random variations of x decreases with increasing n; in other words, the dispersion of the results of strength tests may be expected to decrease with increasing specimen size. This may be expressed quantitatively as follows :—

The variance σ_{η}^2 of the random variable η is given by

$$\sigma_{\eta}^2=\int_0^{\infty}(\log_e t)^2 \, . \, e^{-t} \, . \, dt-\left(\int_0^{\infty}\log_e t \, . \, e^{-t} \, . \, dt\right)^2=\frac{\pi^2}{6}$$

where $t=e^{\eta}$ as above.

The variance of x is

$$\left(\frac{\delta x}{\delta \eta}\right)^2 . \, \sigma_{\eta}^2=\frac{\pi^2}{6\lambda^2}$$

and the variance, σ_x^2, of S is

$$\left(\frac{\delta S}{\delta x}\right)^2\sigma_x^2=\frac{k^2\pi^2}{24\lambda^2}\frac{1}{\bar{x}^3}.$$

Since n is assumed to be large, the mode may be taken as the mean value of x and the standard deviation of the strength is

$$\sigma_s=\frac{\pi}{2\lambda\sqrt{6}}\frac{S^3}{k^2} \; . \; . \; . \; . \quad (15a)$$

i.e. the standard deviation should increase approximately as the cube of the mean (or most probable) strength as the result of random variations in the maximum flaw size alone.

$$\text{As } S=\frac{k\lambda^{\frac{1}{2}}}{\sqrt{\log_e n}}, \; k^2\lambda=S^2\log_e n \, .$$

Substituting this value in (15*a*) gives

$$\log_e n=\frac{\pi}{2\sqrt{6}}\frac{S}{\sigma_s} \quad . \; . \quad (16a)$$

a result which is also used above.

(*b*) *Normal Distribution.*—The problem here is one of smallest values, and

$$f(x)=\frac{1}{\sqrt{2\pi}.\sigma}e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where μ is the mean strength and σ the standard deviation for the unit size. Simplifying by putting

$$\theta=\frac{x-\mu}{\sigma\sqrt{2}}$$

$$f(x)=\frac{1}{\sqrt{2\pi}.\sigma}e^{-\theta^2}, \; f^2(x)=\frac{1}{2\pi\sigma^2}e^{-2\theta^2}$$
$$\text{and } f'(x)=\frac{-\theta}{\sigma^2\pi}e^{-\theta^2}.$$

The value of $F(x)$ cannot be obtained by direct integration but for large negative values of θ (i.e. for values of x much smaller than the mean μ, which are the ones chiefly of interest) an approximate solution is

$$F(x)\simeq\frac{-e^{-\theta^2}}{\sqrt{\pi}.2\theta}.$$

Substituting these values for $f^2(x)$, $f'(x)$ and $F(x)$ in equation (8*a*), the following approximate solution is obtained :—

$$x^*=\mu-\sigma(2\log_e n)^{\frac{1}{2}}+\frac{\sigma(\log_e\log_e n+\log_e 4\pi)}{2(2\log_e n)^{\frac{1}{2}}}.$$

For the large values of n the approximate distribution of the smallest values of x may

results. The case of 42ft square by 20ft high pillars may be taken as an example.

The average strength of specimens with a side length of 42ft and a slenderness ratio of 0·5 is estimated to be 460 tons per square foot (Table VI). The value of the constant B in the slenderness ratio equation for this side length may then be calculated from

$$460=0\cdot0121B^2+\frac{B}{0\cdot5}$$

giving

$$B=129 \text{ tons per square foot.}$$

The mean strength S of pillars with this side length and any slenderness ratio R is thus given by

$$S=201+\frac{129}{R}.$$

When the pillar height is 20ft the mean compressive strength is therefore

$$201+129\,.\,\frac{42}{20}=472 \text{ say } 470 \text{ tons per square foot.}$$

GENERAL DISCUSSION

(*a*) *Size of Flaws in Anhydrite.*—It is of interest to estimate the sizes of the flaws which, according to Griffith's theory, would give some of the observed compressive strengths. This requires values of s_0, E and T for substitution in equation (1). The specific surface energy of rocks is usually of the order of 10^3 ergs per square centimetre. The ultrasonic pulse velocity in several types of anhydrite is $4\cdot4\times10^5$ cm per second ; if Poisson's ratio is assumed to be 0·2, Young's modulus is about 5×10^{11} dynes per square centimetre. The tensile strength can be estimated for the cross section and sample in question from the value of the parameter A, for, according to Griffith[9] the tensile strength of a brittle material is one-eighth of its compressive strength. For example, the estimated tensile strength of 1in square specimens of 207 anhydrite is about 1 ton per square inch in reasonable agreement with values of about ½ ton per square inch observed in tensile tests (parallel to the bedding) on similar types of stone. If the flaws are assumed to be actual cracks, substitution of the approximate values in equation (1) gives a crack length of approximately 300μ for a 1in square section of 207 anhydrite and 600μ for a ½in square section of 204 anhydrite. These figures are necessarily very approximate, but it is of interest that they are commensurate with the diameter of the largest crystal that would be present in specimens of the size to which they refer. The crack length required to give strengths of the order calculated for pillars would be about 0·4cm.

(*b*) *Nature of the Flaws in Anhydrite.*—Generally, a flaw may be regarded as any type of discontinuity or inclusion which magnifies locally the applied stress. A possible interpretation of the relation between flaw and crystal size in brittle crystalline materials is that the flaws are cleavage cracks. The stress conditions arising from this type of crack have been investigated by Elliott,[17] who found that it gives the same fracture condition, with only slightly different values of the numerical factors, as Griffith's elliptical crack. It is not known whether the critical step in producing fracture is the initiation of crack propagation within a crystal or propagation across the crystal boundary into the next. In the former case, if the flaws are cleavage cracks, cleavages must exist in the specimen before stressing ; in the latter case, the flaws may be partly or wholly engendered during stress application. As anhydrite is a readily cleavable mineral (perfect (010) and distinct (100) cleavages) it seems possible that the flaws in it are cleavage cracks ; the explanation of pre-existing cleavages, if necessary, would present no difficulty since these could readily arise from local stresses resulting from recrystallisation, hydration or dehydration of the parent deposit during its geological history.

The possibility that the flaws are produced by stress release when the anhydrite is mined cannot be entirely excluded. In this event there would be no size effect in the *in situ* material and the pillar strengths would be considerably greater than those calculated above. It would manifestly be unwise to make this assumption for practical purposes.

During the tests on run-of-mine stone it was observed that the strength characteristics of specimens containing gypsum porphyroblasts closely resembled those of specimens with a similar anhydrite crystal texture, but free from porphyroblasts. The porphyroblasts do not, therefore, appear to act as large and sparse flaws, for otherwise the strength of anhydrite containing them would be much lower and much more variable than that of gypsum-free anhydrite. This failure to act as flaws is possibly due to gypsum being far too weak to transmit the relatively intense stress necessary to initiate a crack in the surrounding anhydrite matrix. The tendency noted in a few tests for strength to decrease slightly with increasing gypsum content may indicate, however, that the porphyroblasts can act as holes in the matrix, thus leading to a small stress enhancement in the surrounding areas.

Also, during these tests, a careful record was kept of the presence or otherwise of macroscopic cracks in the specimens. No correlation was found between strength and the severity of these macroscopic flaws, extensively cracked specimens giving strengths higher than the mean for the particular sample of stone as frequently as below the mean in the same manner as the apparently uncracked specimens.

(*c*) *Limitations of the Chain Model.*—Although the simple chain model accounts fairly satisfactorily for the size effect in specimens of constant slenderness ratio, there is little doubt that it presents an oversimplified picture, particularly when changes of slenderness ratio are involved. There are variations of stress within a compressed specimen and the stress distribution probably changes with slenderness ratio. The weakest link hypothesis is obviously only tenable, in its simplest form, so long as all of the flaws are subjected to the same stress as are the links in a tensioned chain. Also, a more satisfactory model would perhaps represent the flaws grouped as a combination of series and parallel units rather than as a single series. In the case of anhydrite and similar materials the situation is further complicated by the anisotropy, for, apart from possible effects on stress distribution, if the orientation of the maximum stress changes with slenderness ratio the effective flaw density and size distribution will also vary. However, it would appear that, in the present state of knowledge in this field, no practical advantage would be gained by attempting to use a more refined model.

(*d*) *Other Applications.*—The application of the statistical theory to other problems of brittle fracture would appear to be worthwhile. A field of great practical importance is that of building materials and the case most worthy of study is, perhaps, that of concrete in which the size effect and accompanying change in strength dispersion were demonstrated over twenty years ago. Attention has recently been refocused on the change of standard deviation of strength with specimen size.[20] The establishment of a satisfactory statistical model may throw further light on the mode of failure of concrete in compression and lead to some modification of present methods of design.

APPENDIX

THE STATISTICS OF EXTREME VALUES AND APPLICATION TO THE CASES CONSIDERED‡

(1) Basic Equations

Suppose that the underlying distribution of a variable x, from whose population samples are to be drawn at random, is given by the continuous probability density function $f(x)$. The associated cumulative distribution function $F(x)$ is then given, in the general case where x may have unlimited positive and negative values, by

$$F(x)=\int_{-\infty}^{x}f(x)dx \quad . \quad . \quad . \quad . \quad (1a)$$

i.e. $F(x)$ represents the probability that the value of a single member lies between $-\infty$ and x.

(*a*) *Largest Values.*—It follows from above that the probability that the values of n individuals selected at random all lie within $-\infty$ and x is $F^n(x)$, i.e. this is the probability for x to be the largest value among the n independent selections. The distribution of the largest values in samples of size n is given by the derivative of $F^n(x)$, which is the probability density function.

$$g_n(x)=\frac{d}{dx}[F^n(x)]=nf(x)[F(x)]^{n-1} \quad . \quad (2a)$$

The last equation enables graphs to be drawn of $g_n(x)$ for a given $f(x)$ from which the mode (most probable value) of the largest value of x in samples of size n can be determined. Alternatively, the mode may be found by solving the equation

$$g_n'(x)=0.$$

Now from (2*a*)

$$g_n'(x)=nf'(x)[F(x)]^{n-1}+n(n-1)f^2(x)[F(x)]^{n-2}=0$$

when $g_n(x)$ is at a maximum. Hence, if a solution exists the mode of x, x_n^*, will be given by

$$f^2(x_n^*)(n-1)=-f'(x_n^*)F(x_n^*) \quad . \quad . \quad (3a)$$

The above equations suffice for the determination of the mode of x and for a general description of the distribution of the largest values in samples of size n drawn from a parent population $f(x)$, but are inadequate for a quantitative study of the distribution of the largest values, particularly for large values of n. For the latter purpose it is convenient to introduce a new random variable defined as

$$\varepsilon=n[1-F(x)] \quad . \quad . \quad . \quad . \quad (4a)$$

In terms of this variable (2*a*) becomes

$$h_n(\varepsilon)=\left(1-\frac{\varepsilon}{n}\right)^{n-1} \quad . \quad . \quad . \quad . \quad (5a)$$

where $h_n(\varepsilon)$ is the probability density function of ε.

The probability density function $h(\varepsilon)$ for very large values of n is conveniently given by

$$h(\varepsilon)=\lim_{n\to\infty}h_n(\varepsilon)=e^{-\varepsilon} \quad . \quad . \quad . \quad . \quad (6a)$$

‡ Useful accounts of the theory of the statistics of extreme values with applications to a variety of problems have been given by Gumbell[18] and Epstein.[21]

Using (4*a*) and (6*a*) the distribution of the largest values in large samples can now be completely specified.

(*b*) *Smallest Values.*—Similar argument to the above shows that the probability that x is the smallest value in a sample of size n is $1-[1-F(x)]^n$ and the derivative of this gives $g_n(x)$, the distribution of the smallest values

$$g_n(x)=nf(x)[1-F(x)]^{n-1} \quad . \quad . \quad (7a)$$

Again, the value of the mode $x_n{}^*$ is given by the solution of $g_n'(x)=0$, which is

$$f'(x_n{}^*)(n-1)=f'(x_n{}^*)[1-F(x_n{}^*)] \quad . \quad (8a)$$

As before, for quantitative examination of the distribution of smallest values it is convenient to introduce a new random variable, defined in this case as

$$\varepsilon=nF(x) \; . \; . \; . \; . \; . \; . \; . \quad (9a)$$

In terms of this variable (7*a*) then becomes

$$h_n(\varepsilon)=\left(1-\frac{\varepsilon}{n}\right)^{n-1} \quad . \; . \; . \; . \quad (10a)$$

where $h_n(\varepsilon)$ is the probability density function of ε. Again, for very large values of n this becomes

$$h(\varepsilon)=e^{-\varepsilon} \; . \; . \; . \; . \; . \; . \quad (11a)$$

(2) Applications

(*a*) *Laplacian Distribution.*—If the probability density function of flaw sizes is $f(x)=\lambda e^{-\lambda x}$, since the minimum possible flaw size is zero the cumulative distribution function is

$$F(x)=\int_0^x \lambda \, . \, e^{-\lambda x}dx=1-e^{-\lambda x}.$$

Also, $f'(x)=-\lambda^2 e^{-\lambda x}$. Substituting these values for $f(x)$, $F(x)$ and $f'(x)$ in equation (3*a*) to find the mode of the largest value of x

$$\lambda^2 e^{-2\lambda x_n{}^*}(n-1)=\lambda^2 e^{-\lambda x_n{}^*}(1-e^{-\lambda x_n{}^*})$$
$$ne^{-\lambda x_n{}^*}=1$$

or

$$x_n{}^*=\frac{\log_e n}{\lambda} \quad . \; . \; . \; . \quad (12a)$$

The exact distribution, $g_n(x)$ of the largest values in samples of size n is given by

$$g_n(x)=n\lambda e^{-\lambda x}(1-e^{-\lambda x})^{n-1}$$

but this is cumbersome to use, except for small values of n. An approximation to the distribution of the largest values when the sample size is large is obtained by introducing the random variable ε, where

$$\varepsilon=n[1-F(x)]=ne^{-\lambda x}.$$

Taking logs and rearranging,

$$x=\frac{\log_e n}{\lambda}-\frac{\log_e \varepsilon}{\lambda} \quad . \; . \; . \quad (13a)$$

where ε is distributed with the probability density function

$$h(\varepsilon)=e^{-\varepsilon}, \; \varepsilon>0.$$

If $\eta=\log_e \varepsilon$, the approximate distribution of x is

$$x=\frac{\log_e n}{\lambda}-\frac{\eta}{\lambda} \; . \; . \; . \; . \quad (14a)$$

where η is distributed as $e^{\eta}.e^{-e^{\eta}}$, $-\infty<\eta<\infty$.

It may be noted that (14*a*) also gives $\frac{\log_e n}{\lambda}$ as the mode of x because the most probable value of η is zero, since

$$\frac{d[h(\eta)]}{d\eta}=\frac{d}{d\eta}e^{\eta} \, . \, e^{-e^{\eta}}=e^{\eta} \, . \, e^{-e^{\eta}}-e^{2\eta} \, . \, e^{-e^{\eta}}=0$$

for maximum $h(\eta)$.
Therefore

$$e^{\eta}=1, \text{ i.e. } \eta=0 \text{ for maximum } h(\eta).$$

Since for any value x of the maximum flaw size, the corresponding strength is $S=kx^{-\frac{1}{2}}$, the expected distribution of strength may be readily obtained. To illustrate the form of the strength distribution curve expected from the above theory and to show the way in which the mode of the strength values decreases with increasing number of flaws, Fig. 14 has been drawn from arbitrarily selected values of the constants k and λ. It should be noted that the results have not been normalised so as to give the same area under each curve, i.e. although the curves give the true relative strength frequencies for a given value of n, the relative frequencies of a given strength for different values of n cannot be directly compared. The slight skewing of the curves towards low strength values should also be noted, as a result of which the mean value and mode do not coincide. Provided n is large, however, the mean and mode may be taken as identical for practical purposes. Thus, the mean value of x for a given n may be calculated from equation (14*a*), since here the random components of x are a function of the random variable η only. The mean value, $\bar{\eta}$ of η is given by

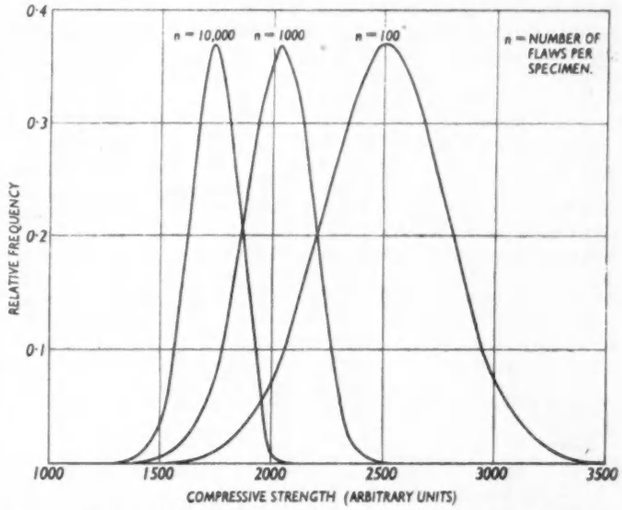

Fig. 14—Theoretical distribution of strengths for Laplacian distribution of flaw sizes

$$\bar{\eta}=\int_{-\infty}^{\infty} \eta_i \, . \, e^{\eta_i} \, . \, e^{-e^{\eta_i}} \, . \, d_{\eta_i}.$$

Putting $t=e^{\eta}$

$$\bar{\eta}=\int_0^{\infty} \log_e t \, . \, e^{-t}dt=-0{\cdot}577.$$

Hence, the mean value of x is

$$\bar{x}=\frac{\log_e n}{\lambda}+\frac{0{\cdot}577}{\lambda}.$$

Provided n is large, the second term on the right-hand side of this equation may be neglected and the mean and mode become identical.

The curves in Fig. 14 also show that the range of strength values to be expected as a result of random variations of x decreases with increasing n; in other words, the dispersion of the results of strength tests may be expected to decrease with increasing specimen size. This may be expressed quantitatively as follows :—

The variance $\sigma_{\eta}{}^2$ of the random variable η is given by

$$\sigma_{\eta}{}^2=\int_0^{\infty}(\log_e t)^2 \, . \, e^{-t} \, . \, dt-\left(\int_0^{\infty}\log_e t \, . \, e^{-t} \, . \, dt\right)^2=\frac{\pi^2}{6}$$

where $t=e^{\eta}$ as above.

The variance of x is

$$\left(\frac{\delta x}{\delta \eta}\right)^2 . \, \sigma_{\eta}{}^2=\frac{\pi^2}{6\lambda^2}$$

and the variance, $\sigma_s{}^2$, of S is

$$\left(\frac{\delta S}{\delta x}\right)^2 \sigma_x{}^2=\frac{k^2\pi^2}{24\lambda^2}\frac{1}{\bar{x}^3}.$$

Since n is assumed to be large, the mode may be taken as the mean value of x and the standard deviation of the strength is

$$\sigma_s=\frac{\pi}{2\lambda\sqrt{6}}\frac{S^3}{k^2} \; . \; . \; . \; . \quad (15a)$$

i.e. the standard deviation should increase approximately as the cube of the mean (or most probable) strength as the result of random variations in the maximum flaw size alone.

$$\text{As } S=\frac{k\lambda^{\frac{1}{2}}}{\sqrt{\log_e n}}, \; k^2\lambda=S^2\log_e n \, .$$

Substituting this value in (15*a*) gives

$$\log_e n=\frac{\pi}{2\sqrt{6}}\frac{S}{\sigma_s} \quad . \; . \quad (16a)$$

a result which is also used above.

(*b*) *Normal Distribution.*—The problem here is one of smallest values, and

$$f(x)=\frac{1}{\sqrt{2\pi}.\sigma}e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

where μ is the mean strength and σ the standard deviation for the unit size. Simplifying by putting

$$\theta=\frac{x-\mu}{\sigma\sqrt{2}}$$

$$f(x)=\frac{1}{\sqrt{2\pi}\,.\,\sigma}e^{-\theta^2}, \; f^2(x)=\frac{1}{2\pi\sigma^2}e^{-2\theta^2}$$

$$\text{and } f'(x)=\frac{-\theta}{\sigma^2\pi}e^{-\theta^2}.$$

The value of $F(x)$ cannot be obtained by direct integration but for large negative values of θ (i.e. for values of x much smaller than the mean μ, which are the ones chiefly of interest) an approximate solution is

$$F(x)\simeq\frac{-e^{-\theta^2}}{\sqrt{\pi}\,.\,2\theta}.$$

Substituting these values for $f^2(x)$, $f'(x)$ and $F(x)$ in equation (8*a*), the following approximate solution is obtained :—

$$x^*=\mu-\sigma(2\log_e n)^{\frac{1}{2}}+\frac{\sigma(\log_e\log_e n+\log_e 4\pi)}{2(2\log_e n)^{\frac{1}{2}}}.$$

For the large values of n the approximate distribution of the smallest values of x may

be obtained by substituting the expression for $F(x)$ in equation (9*a*), giving as an approximate solution

$$x = x^* + \frac{\sigma}{(2 \log_e n)^{\frac{1}{2}}} \log_e \varepsilon.$$

As the random components of x are a function of the random variable ε only, the mean value of x, $\bar{x}$, is given by

$$\bar{x} = x^* - \frac{0{\cdot}577\sigma}{(2 \log_e n)^{\frac{1}{2}}}$$

and again, for large values of n, the mean and mode may be considered identical without serious error. It also follows that the standard deviation of x, σ_x, is given approximately by

$$\sigma_x = \sigma \frac{\pi}{(12 \log_e n)^{\frac{1}{2}}} \quad . \quad . \quad . \quad . \quad (17a)$$

provided n is large. Accurate values of the ratio σ_x/σ for a large range of n have been calculated by Tippett.[19] Comparison of these with the values given by (17*a*) shows that for the values of n which are of interest here ($n \leqslant 8$) no appreciable error is introduced by using the values given by (17*a*).

(*c*) *Weibull Distribution.*—Here

$$f(x) = \alpha\beta x^{\beta-1} \cdot e^{-\alpha x^{\beta}} \quad . \quad . \quad . \quad (18a)$$

where α and β are constants and $x \geqslant 0$, $\alpha > 0$, $\beta > 1$.

Now

$$F(x) = \int_0^x \alpha\beta x^{\beta-1} \cdot e^{-\alpha x^{\beta}} \cdot dx = 1 - e^{-\alpha x^{\beta}}$$

and

$$f'(x) = e^{-\alpha x^{\beta}} [\alpha\beta(\beta-1)x^{\beta-2} - \alpha^2\beta^2 x^{\beta-1}]$$

$$\alpha^2\beta^2 x^{*2(\beta-1)} \cdot e^{-2\alpha x^{*\beta}} (n-1)$$

$$= [\alpha\beta(\beta-1)x^{*\beta-2} - \alpha^2\beta^2 x^{*\beta-1}] e^{-2\alpha x^{*\beta}}$$

from which

$$x^* = \left[\frac{1 - \frac{1}{\beta}}{n\alpha}\right]^{\frac{1}{\beta}} \quad . \quad . \quad . \quad . \quad (19a)$$

It is not necessary to know the unit size (i.e. the size for which (18*a*) gives the distribution of strengths) in order to express results by means of equation (19*a*). This equation may be rewritten

$$S = \frac{b}{n^{1/\beta}}$$

where S, the most probable strength, replaces x^* and b is a constant given by

$$b = \left[\frac{1 - \frac{1}{\beta}}{\alpha}\right]^{\frac{1}{\beta}}$$

Now n, the number of units in the specimen whose strength is S, is given by

$$n = \frac{V}{V_0}$$

where V is the volume of the specimen of strength S and V_0 is the volume of the unit size.

Hence,

$$S = \frac{b}{\left(\frac{V}{V_0}\right)^{\frac{1}{\beta}}}.$$

Taking logarithms

$$\text{Log } S = K - \frac{1}{\beta} \log V \quad . \quad . \quad . \quad (20a)$$

where K is a constant given by $K = \log b V_0^{1/\beta}$, and is numerically equal to the most probable strength of a specimen of unit volume and with the slenderness ratio in question.

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Design of Stiffened Plating in Compression

By J. C. CHAPMAN, Ph.D., A.M.I.C.E. and JEAN E. SLATFORD, B.A.

Simple formulæ governing the buckling of simply-supported stiffened plating are applied to some practical examples which may be relevant to ship design. The variation in critical stresses caused by changing the distribution of the stiffening members between the transverse and longitudinal directions is illustrated. For the transversely-stiffened plate selected it is concluded that, by introducing longitudinal stiffeners and reducing the transverse stiffening, the total weight can be reduced by 8 per cent while maintaining the same overall buckling load. A greater saving can be achieved by reducing the plate thickness. Alternatively, by maintaining the same weight the overall buckling load can be increased three times. The buckling stress of a single panel of plating is also increased when longitudinal stiffeners are introduced. When considering the implication of longitudinal stiffening, it should be borne in mind that the post-buckling reserve of strength (in the elastic range) is less when longitudinal stiffeners are employed. No consideration has been given either to post-buckling behaviour or to the effect of transverse bending.

THE theoretical basis governing the critical buckling of stiffened plating is well known, and numerous papers on the subject have been published. In practical ship design it is probably not possible to arrive at plate-stiffener combinations of optimum buckling efficiency, since the plate thickness is determined largely by considerations other than its behaviour in compression in its own plane (e.g. wave pressure, local impact, and corrosion). This article gives some simple formulæ for the compressive buckling stresses of stiffened plating, and illustrates their application to practical design. The formulæ have been taken from a paper dealing with the post-buckling behaviour of stiffened plating,* since these are familiar to the authors and seem to have the merit of simplicity. They are based on the assumptions that the edges of the plate are simply supported, that the torsional rigidity of the stiffeners can be neglected, and that the plate is loaded only in its own plane. In the present paper no consideration is given to post-buckling behaviour.

The first example is representative of part of a ship's deck plating, stiffened only in the transverse direction. Further examples show how the buckling loads and weights are affected by changes in the arrangement of stiffeners. The object of this note is to focus attention on a simple procedure which enables the designer to improve the compressive efficiency of stiffened plating without losing sight of other requirements.

* "Compressive Buckling of Stiffened Plates," Falconer, B. H. and Chapman, J. C., THE ENGINEER, London, June 5, 1953, pages 789 and 822.

Nomenclature

a—Plate dimension in longitudinal direction.
b—Width of plate.
t—Plate thickness.
l—Half wave-length of buckling.
$\lambda = l/b$—Parameter representing half wavelength.
I_x—Combined moment of inertia of plate and longitudinal stiffeners per unit length.
I_y—Combined moment of inertia of plate and transverse stiffeners per unit length.
I—Moment of inertia of plate per unit length.
E—Modulus of elasticity of material in tension or compression.
ν—Poisson's ratio.
σ_c—Critical stress.
P_c—Critical load per unit width.
a_x—Cross-sectional area of stiffeners in direction x relative to plate area.
$\beta_x = (1-\nu^2)\frac{(I_x - I)}{I}$—Parameter representing rigidity of longitudinal stiffeners.
$\beta_y = (1-\nu^2)\frac{(I_y - I)}{I}$—Parameter representing rigidity of transverse stiffeners.

MODES OF BUCKLING

A stiffened plate may buckle overall as a plate-stiffener combination, or buckling may occur locally. The overall buckling stress for a stiffened plate is given by

$$\sigma_c = \frac{\pi^2 E}{12(1-\nu^2)} \frac{t^2}{b^2} \frac{1}{(1+\alpha_x)} \left[\frac{(1+\beta_x)}{\lambda^2} + (1+\beta_y)\lambda^2 + 2\right] \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and for an infinitely long plate

$$\lambda = \sqrt[4]{\frac{1+\beta_x}{1+\beta_y}} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

A plate of finite length a will buckle into a number of equal half waves of length l, and the number of half waves $a/l = a/\lambda b$ must be a whole number (Fig. 1a). It follows that in general λ is not given exactly by Equation (2), and must be determined by having regard to the length of plate, although for fairly long plates Equation (2) is sufficiently accurate. For shorter plates the procedure is to find if the wave-length $l = \lambda b$ given by Equation (2) fits the known plate length (i.e. to find if the number of half waves a/l is a whole number). If not, the value of λ is adjusted slightly. For example, if a plate of length 100in and width 50in has a value of $\lambda = 0{\cdot}3$ (Equation (2)) the half wave-length l is 15in, and it is then necessary to decide whether in fact the plate buckles into six half waves, corresponding to $l = 16{\cdot}7$in, or seven half waves, corresponding to $l = 14{\cdot}3$in. In the first case, $l/b = \lambda = 0{\cdot}333$, and in the second case $\lambda = 0{\cdot}286$. Since $0{\cdot}286$ is nearer $0{\cdot}3$ than is $0{\cdot}333$, it is likely that $0{\cdot}286$ is the correct value for λ; but this can be checked by finding the value of σ_c corresponding to each value for λ. The correct value of σ_c is the smaller of the two.

Where the plate is sufficiently long for Equation (2) to hold, substitution in Equation (1) gives

$$\sigma_c=\frac{\pi^2E}{6(1-\nu^2)}\frac{t^2}{b^2}\frac{1}{(1+\alpha_x)}\left[\sqrt{(1+\beta_x)(1+\beta_y)}+1\right] \quad . \quad . \quad . \quad . \quad . \quad (3)$$

This equation has been used for the numerical examples since it seemed undesirable to introduce any particular length of plate.

Where heavy longitudinal stiffeners are widely spaced, buckling of the plate and transverse stiffeners may occur between longitudinals (Fig. 1b). The critical stress for this mode of buckling (or when there are no longitudinals) can be found from Equation (1) or Equation (3), by writing $\beta_x=\alpha_x=0$.

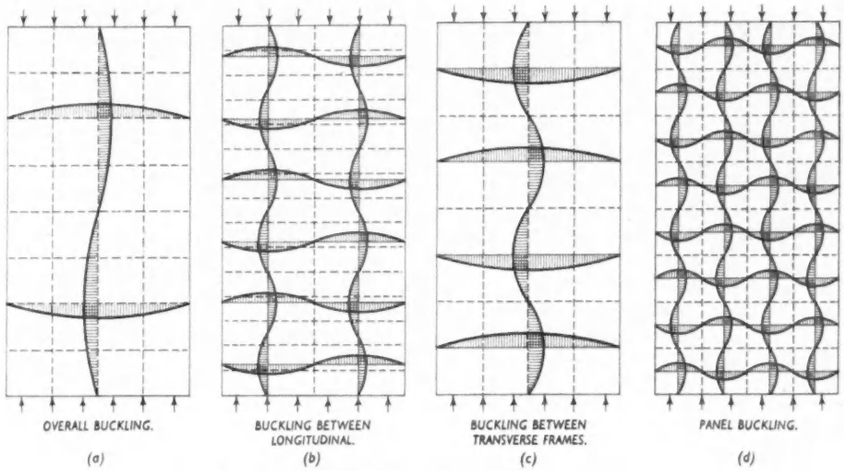


Fig. 1—Modes of plate buckling. Broken lines represent stiffeners

If the transverse frames are widely spaced, buckling of the plate and longitudinal stiffeners may occur between frames (Fig. 1c), and the buckling stress for this condition (or when there are no transverse stiffeners) can again be found from Equations (1) or (3) by writing $\beta_y=0$. It often happens that the frame spacing is less than the width of the plate, in which case the half wave-length is restricted to the frame spacing. If the frame spacing is a, Equation (1) becomes

$$\sigma_c=\frac{\pi^2E}{12(1-\nu^2)}\frac{t^2}{b^2}\frac{1}{(1+\alpha_x)}\left[(1+\beta_x)\left(\frac{b}{a}\right)^2+\left(\frac{a}{b}\right)^2+2\right] \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If the frame spacing is greater than the breadth, the wave-length is determined as before.

Single panels of plating may buckle between frames and longitudinals (Fig. 1d), and the buckling of an unstiffened panel is given by

$$\sigma_c=\frac{\pi^2E}{12(1-\nu^2)}\frac{t^2}{b^2}\left[\frac{1}{\lambda}+\lambda\right]^2 \quad . \quad . \quad (5)$$

For an infinitely long plate $l=b$ or $\lambda=1$, but for plates of finite length a/l must be a whole number. In this case it is unnecessary to calculate more than one value of σ_c, as the correct value of λ can be found directly. The number of half waves a/l will be the nearest whole number above or below a/b, and the transition between the two alternative wave forms occurs at

$$\left(\frac{a}{b}\right)_{\text{transition}}=\sqrt{\left(\frac{a}{b}\right)_{(-)}}\sqrt{\left(\frac{a}{b}\right)_{(+)}},$$

where $(a/b)_{(-)}$ is the nearest whole number below, and $(a/b)_{(+)}$ is the nearest whole number above the actual value of a/b. The correct number of half waves is determined by whether the value of a/b is greater or less than the value of $(a/b)_{\text{transition}}$. Suppose, for example, that $a/b=1\cdot5$; the plate will buckle into either one or two half waves, and $(a/b)_{(-)}=1$, $(a/b)_{(+)}=2$, so $(a/b)_{\text{transition}}=\sqrt{1}\sqrt{2}=1\cdot41$. Since $1\cdot5$ is greater than $1\cdot41$, the plate will buckle into two half waves, and $\lambda=0\cdot75$.

Where the length a is less than the breadth b, the half wave-length $l=a$, and Equation (5) becomes

$$\sigma_c=\frac{\pi^2E}{12(1-\nu^2)}\frac{t^2}{b^2}\left[\frac{b}{a}+\frac{a}{b}\right]^2 \quad . \quad . \quad . \quad (6)$$

Numerical Examples

In the examples the stiffeners are toe-welded. The first plate-stiffener combination is typical of a ship's deck.

Arrangement (1)—*0·62in plate, 120in wide, stiffened transversely by 7in by 4in by ⅜in angles at 30in centres :*

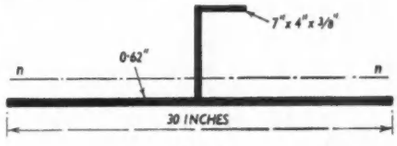


Fig. 2

Cross-sectional area of plate per stiffener $18\cdot6$ square inches.

Area of stiffener $4\cdot0$ square inches.

Weight of combination $30\cdot1$ lb per square foot.

Second moment of area about nn, assuming all the plate acts in conjunction with the angle, per inch width

$$I_y=3\cdot38 \text{ cubic inches}$$

Second moment of area of plate, per inch width,

$$I=0\cdot0200 \text{ cubic inch.}$$

Assuming $\nu=0\cdot3$

$$\beta_y=(1-\nu^2)\left(\frac{I_y}{I}-1\right)=153.$$

Since there are no longitudinal stiffeners $\alpha_x=\beta_x=0$, and assuming the plate is sufficiently long for Equation (3) to hold

$$\sigma_c=\frac{\pi^2E}{6(1-\nu^2)}\frac{t^2}{b^2}\left(\sqrt{1+\beta_y}+1\right);$$

$b=120$in, and for E=13,000 tons per square inch the overall buckling stress is

$$\sigma_c=8\cdot4 \text{ tons per square inch}$$

The overall buckling *load* per inch width is

$$P_c=8\cdot4\times0\cdot62=5\cdot2 \text{ tons per inch}$$

The buckling stress for a panel of plating between transverse stiffeners is given by Equation (6), where $a=30$in, and

$$\sigma_c=5\cdot7 \text{ tons per square inch}$$

This stress corresponds to a load

$$P_c=3\cdot5 \text{ tons per inch}$$

It can be seen that buckling between frames occurs first. As the half wave-length for overall buckling is only 34in, it is almost certain that the 30in half wave-length would persist even if the overall buckling stress were exceeded.

The second combination is chosen to provide the same overall buckling load as the first, the stiffeners being equally disposed in the longitudinal and transverse directions.

Arrangement (2)—*0·62in plate, 120in wide, stiffened transversely and longitudinally by 3in by 2in by ¼in angles at 30in centres :*

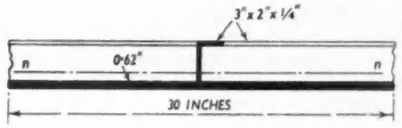


Fig. 3

Cross-sectional area of plate per stiffener $18\cdot6$ square inches.

Area of stiffener $1\cdot19$ square inches

$$\alpha_x=0\cdot064.$$

Weight of combination $28\cdot0$ lb per square foot.

Second moment of area about nn, assuming all the plate acts in conjunction with the angle, per inch width

$$I_x=I_y=0\cdot257 \text{ cubic inch}$$

$$I=0\cdot0200 \text{ cubic inch}$$

$$\beta_x=\beta_y=\beta, \text{ say}$$

and Equation (3) becomes

$$\sigma_c=\frac{\pi^2E}{6(1-\nu^2)}\frac{t^2}{b^2}\frac{(2+\beta)}{(1+\alpha_x)};$$

$\beta=10\cdot9$, and the overall buckling stress is

$$\sigma_c=7\cdot6 \text{ tons per square inch.}$$

The buckling load per inch width is

$$P_c=\frac{7\cdot6\times19\cdot8}{30}=5\cdot0 \text{ tons per inch.}$$

A single 30in square panel of plating buckles into one half wave, and Equation (5) becomes

$$\sigma_c=\frac{\pi^2E}{3(1-\nu^2)}\frac{t^2}{b^2},$$

from which

$$\sigma_c=20 \text{ tons per square inch}$$

and

$$P_c=13\cdot2 \text{ tons per inch.}$$

The overall buckling load is about the same as before, but the local buckling load has been greatly increased.

In the following example the spacing between transverse stiffeners is increased, while maintaining the same buckling load.

Arrangement (3)—*0·62in plate, 120in wide, stiffened transversely by 3½in by 2½in by ⅝in by ⅛in angles at 60in centres, and longitudinally by 3in by 2in by ¼in angles at 30in centres :*

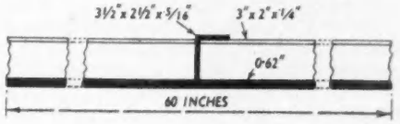


Fig. 4

Area of plate per transverse stiffener 37·2 square inches.

Area of transverse stiffener 1·78 square inches.

As in Arrangement (2) $\alpha_x = 0{\cdot}064$.

Weight of combination 27·6 lb per square foot.

$$I_y = 0{\cdot}260 \text{ cubic inches}$$
$$\beta_y = 11{\cdot}0,$$

and as in Arrangement (2)

$$\beta_x = 10{\cdot}9.$$

From Equation (3)

$$\sigma_c = 7{\cdot}6 \text{ tons per square inch}$$
$$P_c = 5{\cdot}0 \text{ tons per inch}$$

The buckling stress for a panel of plating is $\sigma_c = 20$ tons per square inch, since $a/b = 2$, and the plate again buckles with its preferred half wave-length $l = b$. The corresponding load is $P_c = 13{\cdot}2$ tons per inch.

As the transverse stiffeners are widely spaced, the buckling of the plate and longitudinals between transverse stiffeners must also be considered. For this mode of buckling $a = 60$in, $b = 120$in, and Equation (4) is applicable, giving

$$\sigma_c = 14{\cdot}7 \text{ tons per square inch}$$
$$P_c = 9{\cdot}7 \text{ tons per inch}$$

For the given overall buckling load and plate thickness no great saving of weight has been achieved by introducing longitudinal stiffeners, but the local buckling load has been increased.

The effect of reducing the plate thickness will now be illustrated.

Arrangement (4)—*0·44in plate, 120in wide, stiffened transversely and longitudinally by 3in by 3in by ¼in angles at 30in centres :*

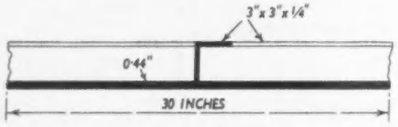


Fig. 5

Area of plate per stiffener 13·2 square inches.

Area of stiffener 1·44 square inches

$$\alpha_x = 0{\cdot}109.$$

Weight of combination 21·4 lb per square foot

$$I_x = I_y = 0{\cdot}294 \text{ cubic inch}$$
$$I = 0{\cdot}0071 \text{ cubic inch}$$
$$\beta_x = \beta_y = 36{\cdot}8.$$

Equation (3) gives the overall buckling stress

$$\sigma_c = 11{\cdot}0 \text{ tons per square inch}$$

and the load per inch width is

$$P_c = 5{\cdot}4 \text{ tons per inch}$$

The buckling stress for a 30in square panel of 0·62in plating is 20 tons per square inch (Arrangement (2)), and for 0·44in plating the panel buckling stress is

$$\sigma_c = 20 \times \left(\frac{0{\cdot}44}{0{\cdot}62}\right)^2 = 10{\cdot}0 \text{ tons per square inch}$$

and

$$P_c = 4{\cdot}8 \text{ tons per inch}$$

The buckling loads are now slightly higher than in Arrangement (1), but the weight is reduced by 30 per cent.

The following arrangement maintains the same plate thickness and total weight as in Arrangement (1), but the transverse stiffener spacing is increased to 60in and the weight so saved is used to provide longitudinal stiffeners at 30in centres.

Arrangement (5)—*0·62in plate, 120in wide, stiffened transversely by 7in by 4in by ⅜in angles at 60in centres, and longitudinally by 3½in by 3in by 5/16in angles at 30in centres :*

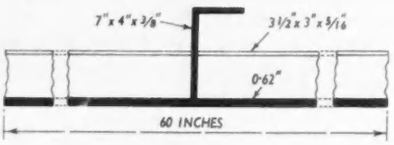


Fig. 6

Area of plate per transverse stiffener 37·2 square inches.

Area of transverse stiffener 4·0 square inches.

Area of plate per longitudinal stiffener 18·6 square inches.

Area of longitudinal stiffener 1·93 square inches

$$\alpha_x = 0{\cdot}104.$$

Weight of combination 30·1 lb per square foot.

$$I_y = 1{\cdot}83 \text{ cubic inches}$$
$$\beta_y = 82{\cdot}7$$
$$I_x = 0{\cdot}545 \text{ cubic inch}$$
$$\beta_x = 24{\cdot}0.$$

From Equation (3), for overall buckling

$$\sigma = 26 \text{ tons per square inch}$$
$$P_c = 18{\cdot}1 \text{ tons per inch}$$

The buckling stress for a 60in by 30in panel of plating is

$$\sigma_c = 20 \text{ tons per square inch,}$$

and

$$P_c = 13{\cdot}7 \text{ tons per inch}$$

Writing $a = 60$in, $b = 120$in in Equation (4) gives the stress for buckling of the longitudinally-stiffened plating between transverse stiffeners

$$\sigma_e = 29 \text{ tons per square inch}$$
$$P_e = 19{\cdot}6 \text{ tons per inch}$$

Compared with Arrangement (1), the overall buckling load has been increased from 5·2 tons per inch to 18·1 tons per inch, and the panel buckling load has been increased from 3·5 tons per inch to 13·7 tons per inch.

The next arrangement again maintains the same total weight as in Arrangement (1), but the stiffeners are distributed equally in the transverse and longitudinal directions at 30in centres.

Arrangement (6)—*0·62in plate, 120in wide, stiffened transversely and longitudinally by 3½in by 3in by 5/16in angles at 30in centres :*

Area of plate per stiffener 18·6 square inches.

Area of stiffener 1·93 square inches.

$$\alpha_x = 0{\cdot}104.$$

Weight of combination 30·0 lb per square foot.

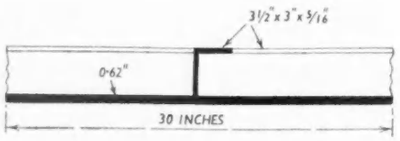


Fig. 7

As in Arrangement (5)

$$\beta_x = 24{\cdot}0 = \beta_y.$$

From Equation (3), for overall buckling

$$\sigma_c = 14{\cdot}7 \text{ tons per square inch}$$

and

$$P_c = 10{\cdot}0 \text{ tons per inch.}$$

The buckling stress for a 30in square panel of plating is

$$\sigma_c = 20 \text{ tons per square inch,}$$

and

$$P_c = 13{\cdot}7 \text{ tons per inch.}$$

Compared with Arrangement (1) the overall buckling load has been increased from 5·2 tons per inch to 10·0 tons per inch.

The following Table summarises the results of the calculations :

Arrangement No.	(1)	(2)	(3)	(4)	(5)	(6)
Plate thickness, inches	0·62	0·62	0·62	0·44	0·62	0·62
Transverse angles :						
Size, inches	7×4×⅜	3×2×¼	3½×2½×5/16	3×3×¼	7×4×⅜	3½×3×5/16
Spacing, inches	30	30	60	30	60	30
Longitudinal angles :						
Size, inches	—	3×2×¼	3×2×¼	3×3×¼	3½×3×5/16	3½×3×5/16
Spacing, inches	—	30	30	30	30	30
Overall buckling :						
Stress, tons per square inch	8·4	7·6	7·6	11·0	26	14·7
Load, tons per inch	5·2	5·0	5·0	5·4	18·1	10·0
Buckling between transverse stiffeners :						
Stress, tons per square inch	5·7	57	14·7	86	29	114
Load, tons per inch	3·5	37	9·7	42	19·6	77
Buckling of plate panel :						
Stress, tons per square inch	5·7	20	20	10·0	20	20
Load, tons per inch	3·5	13·2	13·2	4·8	13·7	13·7
Weight, lb per square foot	30·1	28·0	27·6	21·4	30·1	30·0
Weight / least buckling load (Arrangement (1)=100)	100	65	64	52	26	35

Conclusions

The numerical examples have been chosen to show how the weight and compressive buckling load of a transversely-stiffened panel may be varied by changing the stiffener arrangement. The examples are intended only to illustrate the type of calculation which may be done in the course of arriving at a suitable design, and the stiffener arrangements chosen are not necessarily the best.

For the transversely-stiffened plate selected it is found that, by retaining the same plate thickness and adding longitudinal stiffeners, the weight of the plate-stiffener combination can be reduced by about 8 per cent, while retaining the original overall buckling load. At the same time, the local buckling load is considerably increased (Arrangements (1), (2), and (3) in the Table). A much greater saving in weight can be achieved by reducing the plate thickness, but it must be remembered that only loading in the plane of the plate has been considered (Arrangement (4)).

If the original plate thickness and total weight is maintained, the overall and local buckling loads can be greatly increased by increasing the spacing or reducing the section of the transverse stiffeners and using the weight so saved to provide longitudinal stiffeners (Arrangements (5) and (6)).

It should be borne in mind that (in the elastic range) the post-buckling reserve of strength of a longitudinally-stiffened plate is less than that of a plate which is only transversely stiffened.

Steel Strip Shear and Classifier Drives at Velindre

The electrical drives for the tinning lines at the Velindre works of the Steel Company of Wales, as supplied by The General Electric Company, Ltd., were described in our issue of August 15, 1958. The shearing and classifier line drives at the ends of the tinning lines, together with some separate cut-up line drives, were supplied by Harland Drives, Ltd., 47/48, Berners Street, London, W.1, working in conjunction with the G.E.C. Below we describe the automatic speed control of the drives and the sheet classification equipment, wherewith the strip is inspected electrically for pinholes and off-gauge material and the cut sheets are then segregated accordingly.

At the Velindre works of the Steel Company of Wales there are three electrolytic tinning lines, each complete with shearing and classifying equipment, built under licence from the United States Steel Corporation ; in addition, there are separate shearing and classifying lines for untinned or " black " plates. The electrical equipment for these lines was supplied and installed by Harland Drives, Ltd., 47/48, Berners Street, London, W.1, in conjunction with The General Electric Company, Ltd.

Two points of particular interest in the electrical installation are dealt with in some detail in this article. The first is the method of controlled raising of the speed of the pay-off reels on the separate shearing lines to compensate for the progressive reduction in coil diameter and maintain constant strip speed. The second is the method of detecting faulty sheets and of automatically diverting them along separate conveyor systems to segregate prime sheets from off-gauge sheets and sheets containing pinholes.

The shearing line receives large coils of cold-rolled, annealed and tempered strip up to a maximum of 72in in diameter and about 32in wide. The thickness of the strip varies from about 0·008in to 0·030in, and the shearing line cuts the strip into sheets varying in the length from 18in to 42in, depending on the speed of the line and the setting of the shear. After the strip has passed through the Hallden Robertson shear (Fig. 1) the cut sheets are then classified on a conveyor system and automatically stacked in three piles, depending on the condition of the sheet—" prime," " off-gauge " and " pinhole." Off-gauge sheets are, as the name implies, ones which are either over or under gauge, as determined by the beta gauge situated on the instrument stand immediately before the shear. These sheets are otherwise of first-class quality and are subsequently hand sorted, according to their gauge, for sale. Pinhole sheets are ones which have small holes generally caused by deposits of slag which occasionally remain in the material after the smelting and hot rolling processes, the slag being broken up in the cold rolling processes at the Velindre works, as a result of which small holes appear.

The shearing line, except for the shear, was built by the Head Wrightson Machine Company, Ltd., and the shear by W. H. A. Robertson and Co., Ltd. Because of the automatic controls, both electrical and mechanical, the line requires an operating crew of only five men and a line has produced 186 tons of sheared plate in an eight-hour shift. The speed of the line is variable between 150ft per minute and 1250ft per minute, but, when in commercial operation, the line is rarely operated at a speed of less than 500ft per minute. The maximum speed of the line is at present limited by the mechanism of the shear to 1000ft per minute and the actual operating speed is determined by the thickness of the sheet being cut and the size of the sheets—that is, the number of cuts of the shear per minute.

The electrical equipment falls under two main headings : first, the driving units and their control gear ; and, secondly, the automatic electronic equipment for rejecting defective sheets.

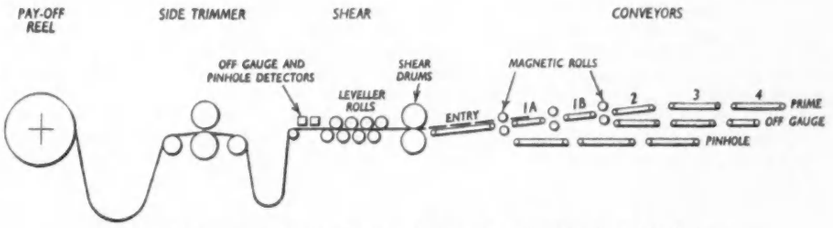


Fig. 2—Diagrammatic layout of steel strip shear and classifier line at Velindre

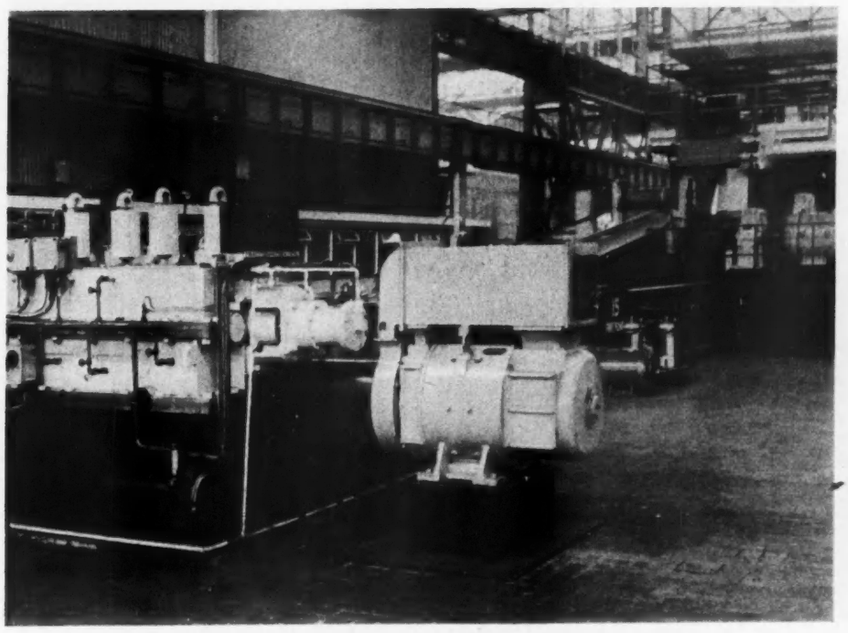


Fig. 1—Shear motor (with closed-air-circuit cooler) on electrolytic tinning line

The Drive

The electrical drive consists of fifteen d.c. motors, coupled to the line as follows :

Pay-off reel	... ...	40 h.p., 480V, 360/1500 r.p.m.
Side trimmer	... ...	20 h.p., 440V, 1690/2190 r.p.m.
Shear...	... ...	75 h.p., 440V, 1000/2000 r.p.m.

Twelve conveyor motors of three different kinds :

(1) 2½ h.p., 440V, 1062/2125 r.p.m.
(2) 6½ h.p., 440V, 1062/2125 r.p.m.
(3) 2½ h.p., 440V, 625/1875 r.p.m.

All the drive motors are supplied from a 125kW variable-voltage generator, armature boosters being associated with the pay-off reel, side trimmers, and one booster for all the conveyor motors. In addition, the main generator set has a 250V level compound exciter and all five machines are driven by a 200 h.p., 3300V squirrel-cage induction motor at 980 r.p.m.

A schematic layout of the line and its associated driving units is shown in Fig. 2.

As the strip is unwound from the pay-off reel, the speed of the pay-off reel motor must be increased to compensate for the reduction in diameter of the coil, so maintaining constant strip speed. There is a pit between the pay-off reel and side trimmer and another pit between the side trimmer and the shear, the sheet hanging in these pits in loops as indicated in Fig. 2. Automatic control of the loops (see Fig. 3) is based on a new approach to the problem, which is stated to have proved very effective in practice.

The speed of the pay-off reel motor is controlled in such a way as to maintain the position of the loop of strip in the looping pit at a particular level. On one side of the pit there is a lamp house containing fluorescent tubes and, on the other side, a photo-electric sensing device is mounted,

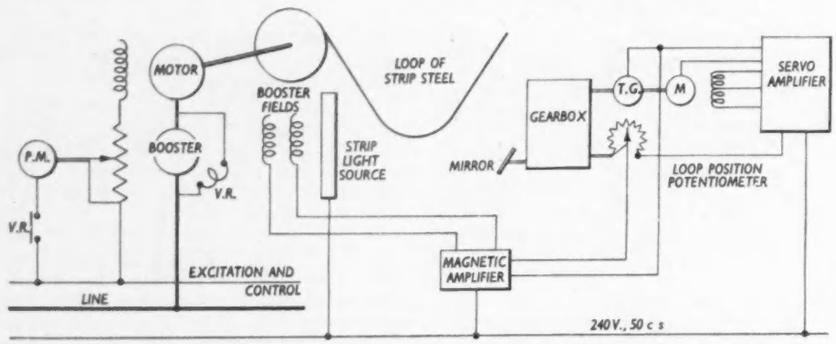


Fig. 3—Automatic control of loops to maintain constant strip speed by increasing the speed of the pay-off reel motor to compensate for the reduction in coil diameter

to respond to the amount of light falling on it from the lamp house ; more or less light is obscured depending on the length of the loop hanging between the lamp house and the sensing device. The photo-electric sensing device consists of a rotatable mirror arranged to reflect light from the lamp house on to the photo-cell. The output voltage from the photo-cell is passed to a thermionic amplifier which, in turn, controls the rotation of a split-field motor driving through a 650/1 reduction gear to the mirror. The mirror always takes up a position such that a predetermined amount of light is reflected on to the photo-cell. Thus, as the loop of strip steel varies in length, the mirror is rotated to follow the bottom of the loop. Geared to the mirror is a potentiometer and the voltage of the sliding contact of the potentiometer is then proportional to the depth of the loop in the pit. The voltage from the potentiometer geared to the motor corresponds to the position of the bottom of the loop and the voltage from a tacho-generator also driven by the split-field servo motor corresponds to the speed and direction of travel of the bottom of the loop. These two voltages are applied to the control windings of a magnetic amplifier which, in turn, controls the current in the two equal, but oppositely connected, field windings of the pay-off reel booster. Hence, the magnitude and polarity of the output voltage of the reel booster varies with the loop position.

The output of the reel booster thus depends on the position of the loop in the pit and varies the speed of the reel motor accordingly. Should the loop tend to increase in length, the mirror will be rotated in a downward direction in quest of more light. The signal applied to the magnetic amplifier controlling the booster will be in such a sense as to reduce the booster voltage (and may even send it negative), thus reducing the speed of the pay-off reel motor and tending to return the position of the loop to the pre-set position. As the strip is paid-off the coil, the speed of the strip tends to fall gradually below line speed as the reel diameter decreases. Thus, the loop in the pit will rise above the control point and a signal from the loop servo unit will produce, through the magnetic amplifier, an increase in positive voltage of the reel booster, causing the speed of the reel motor to rise to the required value. The process of increasing booster voltage will continue, associated with the shortening of the length of the loop, until the booster voltage has reached a value of approximately 28V when a voltage relay will energise the pilot motor of the pay-off reel field rheostat. The pilot motor will run the rheostat arm in such a direction as to weaken the field of the reel motor. As the field is weakened, the speed of the reel motor will increase tending to cause the loop to drop in the pit. This will, through the magnetic amplifier, produce a reduction in the booster voltage and, when the voltage has fallen to about 20V, the voltage relay will drop out and stop the pilot motor. The pay-off reel motor will then be running with a slightly weakened field and a small voltage from the booster. As the coil unwinds further the sequence of operations described above will be repeated until the reel is empty. Then the reel motor will be running on weak field, that is, 1360 r.p.m. corresponding to a line speed of 1250ft per minute, whereas with a full coil, the reel motor speed would be 360 r.p.m.

Automatic run-back of the reel field rheostat is initiated by operation of the lever controlling the hydraulics for expanding the reel mandrel when fitting a new coil to the pay-off reel.

The control of the loop between the side trimmer and the shear is in general similar to that of the pay-off reel/side trimmer loop except that there is no controlled shunt range on the side trimmer motor. The loop control is achieved wholly on the side trimmer booster : control of the looping pit maintains the loop at the pre-set level.

All the conveyor motors are provided with automatic speed control, the speed reference being taken from a small tacho-generator driven from the shear pinch rolls. The output from this tacho-generator being small, it is amplified by a magnetic amplifier and applied to the control of a 5kW generator (Fig. 5) in such a way that the voltage from this 5kW machine is proportional to line speed ; this voltage is used as a reference for all conveyor motors.

The output of the tacho-generator coupled to each of the conveyor motors is proportional to the speed of the conveyor motor and the output is compared, across a potentiometer circuit (*SSR* and *PR*, Fig. 5) with the controlled reference voltage from the line tacho-generator set. Any difference is fed to the particular magnetic amplifier (*MA*) as an error signal, and the output from the magnetic amplifier supplies the conveyor motor field. Should the speed of the conveyor motor fall below the pre-set value, the output from the magnetic amplifier will be such as to weaken the field of the conveyor motor and thus increase its speed. The controlled speed of the conveyor motors may be adjusted by changing the position of the speed-setting potentiometer (*SSR*), that is, changing the effective reference voltage from the line tacho-generator for that particular conveyor motor.

The speed of the classifier entry section must be faster than that of the shear section so that a gap is obtained between the cut sheets as they come from the shear on to the entry conveyor. Variation of the gap between the sheets is provided from zero gap to a maximum gap of approximately 5in by means of a rheostat (*GSR*). Maintenance of the gap between the sheets on the entry conveyor, conveyor 1A and conveyor 1B is important for satisfactory operation of the automatic sheet rejection equipment.

At the end of the entry conveyor there is a set of magnetic rolls (Fig. 4) constituting a deflection point for the pinhole sheets ; and at the end of conveyor 1B, there is a second set of magnetic rolls at the rejection point for off-gauge. The conveyors immediately after each rejection point on each of the three flights are run at the same speed as the entry section conveyor or slightly faster to ensure

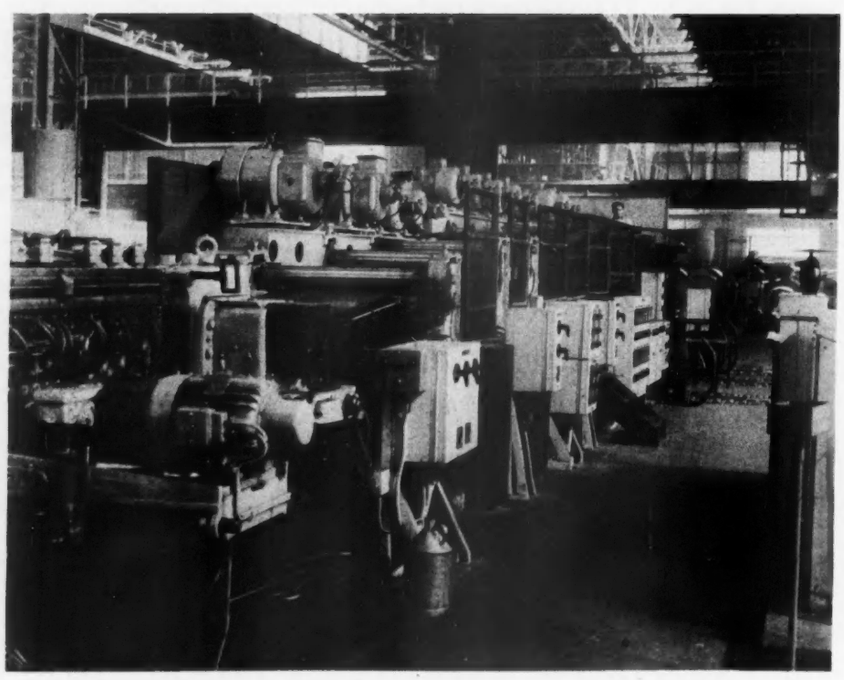


Fig. 4—Conveyor motor and controls on "black" plate shearing lines. Three magnetic rolls can be seen (centre) and the selsyn linking the leveller rolls and recording drum is on the left

that the sheets clear these points without causing "cobbling." At the end of each No. 2 conveyor a shingling plate is situated which deflects the sheet slightly upwards, thus raising the leading edge of the sheet above the trailing edge of the preceding sheet and allowing the sheets to overlap or "shingle." The speeds of the No. 3 conveyors are about 50 per cent of the No. 2

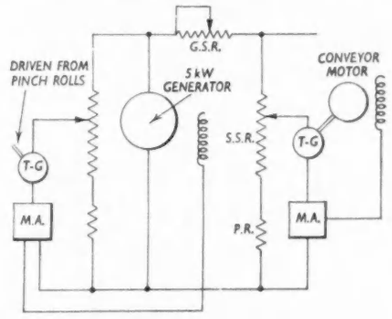


Fig. 5—Automatic speed control of conveyor motors. The output from a tachogenerator coupled to each conveyor motor is compared with that of a tachogenerator driven from the shear pinch rolls. Through a magnetic amplifier any difference is applied as an error signal to the field of the appropriate conveyor motor to correct its speed

conveyor speeds. The No. 4 conveyors are run even slower, being between 20 and 25 per cent of the line speed, depending on the length of sheet being cut. Thus the overlap on the final conveyor is such that three thicknesses of sheet are passing a particular point at any instant. The object of this "shingling" is to ensure satisfactory piling of the cut sheets into the boxes situated at the end of each conveyor flight.

Automatic Rejection of Defective Sheets

The basic function of the equipment for rejecting defective sheets is to detect pinholes and off-gauge portions in the strip before cutting into sheets, store the knowledge and then, at the appropriate time, emit a signal, which will deflect the cut sheets on to the appropriate conveyors.

The pinhole detector is a photo-electric device supplied direct from the U.S.A. and the off-gauge detector is a beta-ray gauge instrument supplied by Davy-United in collaboration with Isotope Developments, Ltd. The remainder of the equipment, apart from the magnetic rolls, was supplied by Harland Drives, Ltd. The single sheet rejection equipment (Fig. 6) consists essentially of :

(*a*) A selsyn link, consisting of a transmitter and receiver, between the leveller rolls and No. 1 recording drum.

(*b*) A selsyn link between the first magnetic roll and No. 2 recording drum.

(*c*) Recording drums Nos. 1 and 2.

(*d*) Electronic switching circuits associated with the off-gauge and pinhole detection and the two recording drums.

(*e*) Thyratrons controlling the power supply to the magnetic rolls.

The channels for the pinhole and off-gauge detection and rejection are completely separate electrically and fundamentally similar. Duplicate channels for stand-by are provided for both the pinhole and off-gauge detection and rejection.

Pinhole Detection Channel.—A small hole in the strip metal will produce a signal from the pinhole detector (*A*, Fig. 6) which is amplified in the first amplifier, a pulse from which will close electronic switch 1. A number of pulses of current will be recorded on drum No. 1. This drum is driven by a selsyn receiver at a speed proportional to the speed of the strip metal, the strip at this stage being continuous. The recorded fault signal is picked up at head 2, amplified and used to "trip" store No. 1 if the sheet about to be cut is faulty. Mounted on the shear is a photo-electric device which gives a pulse at the instant the shear knives cut the sheet. The knives of the shear cut once every revolution of the shear drums. The resultant pulse is amplified and used to re-set store No. 1 from the "tripped" condition and this action produces a pulse which closes electronic switch No. 2.

The distance between head 1 and head 2 on No. 1 recording drum is proportional to the distance between the centre line of the pinhole detector and the centre line of the shear. Thus, as this drum is rotating at a speed proportional to strip speed, the time taken for the detected pinhole to travel from the pinhole detector to the centre line of the shear is the same as the time taken for the signal recorded at head 1 to reach replay head No. 2. Thus, when the signal is picked off the record drum by head No. 2, the pinhole has reached the centre line of the shear and, shortly after this, a signal is received from the shear detector photo-electric cell at the instant of cut and this locates the trailing edge of the sheet containing the pinhole. For sheet rejection, it is necessary to know the position of the leading edge of the sheet and, to do this, a leading edge detector photo-electric cell is positioned after the shear, on the entry conveyor, in such a position that it is possible to have only one sheet between the leading edge detector and the centre line of the shear.

With switch No. 2 closed, the interruption of the light on the leading edge detector photo-cell by the leading edge of the faulty sheet produces a pulse which opens electronic switch No. 3 whereupon recording ceases for the length of the sheet.

No. 2 recording drum is driven at a speed proportional to the speed of the entry conveyor and the distance between head 3 and head 4 is proportional to the distance between the centre line of the leading edge detector and the magnetic rolls. The recording signal picked up by head 4 is rectified and is used to operate the thyratron switch. When a rectified recording current is present the thyratron switch energises the top magnetic roll which passes the sheet on to the top or prime conveyor, that is, the sheets being passed are good sheets. As mentioned previously, when a faulty sheet passes the leading edge detector, a pulse opens electronic switch 3 and recording ceases for the length of the sheet. The circuit is so arranged that if there is no output from the rectifier fed from head No. 4 the thyratron switch will energise the bottom roll and, therefore, deflect the sheet on to the pinhole conveyor.

Off-Gauge Sheet Rejection.—The system for rejection of off-gauge sheet is basically the same as that for the pinhole channel except that with off-gauge the final switching is arranged to reject several sheets since, unlike a pinhole, off-gauge usually occurs over a considerable length.

We learn that this system has proved satisfactory in service and that it has rejected single pinhole sheets at speeds up to 950ft per minute. This is thought to be a considerable improvement on the electromagnetic methods previously employed where, with a single pinhole sheet, four or more sheets were rejected to ensure rejection of one faulty sheet. On previous installations it was profitable to hand-sort the pinhole sheets after rejection to reclaim the prime sheets in the pinhole pile but this hand sorting is no longer necessary.

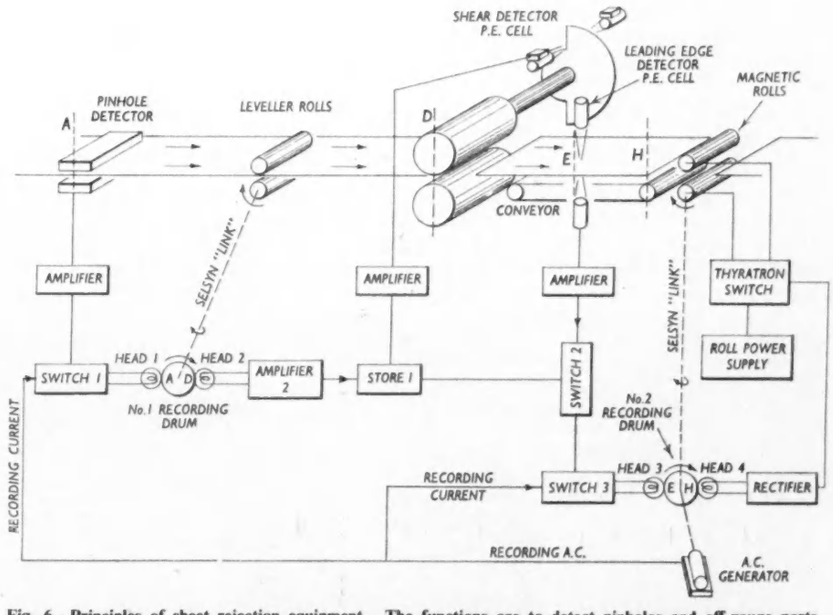


Fig. 6—Principles of sheet rejection equipment. The functions are to detect pinholes and off-gauge parts of the strip before cutting into sheets, to store this data, and then to emit a signal which will deflect the faulty sheets to the appropriate conveyors

The equipments supplied for use with continuous tinning lines are similar in operation. In this case, the shear and classifier section supplied by Harland Drives, Ltd., followed the tinning section of the installation, the drive of which was supplied by The General Electric Company, Ltd. (The Engineer, August 15, 1958, page 262). The shear and classifier section obtains a speed signal from a tacho-generator driven by the

exit bridle rolls and this signal is fed to a thermionic amplifier which controls the field of the 125kW generator supplying all motors on the shear and classifier section. The strip is received continuously from the tinning line ; as there are no coils, there is, therefore, no pay-off reel or side trimmer and only one loop between the carry-over conveyor at the end of the tinning lines and the shear. The loop control servo unit is fundamentally the same as that installed on the shear and classifier lines but, in this case, the output from the loop control is either added to or subtracted from the speed signal received from the tacho-generator mentioned previously. Thus, the signal from the tacho-generator is a base signal for the speed control. The output from the loop servo unit acts as a vernier about the base signal adjusting the output from the main generator and thus the speed of the shearing line, so that the speed of the strip entering the looping pit from the carry-over conveyor is the same as the rate at which it is being pulled out of the pit by the shear.

The single-sheet rejection equipment on the tinning line is also fundamentally the same as that supplied for the shear and classifier line except that additional safeguards have been incorporated, such as monitoring the pinhole signals and automatic changeover from No. 1 channel to No. 2 channel in the event of a failure, as the tinning line process is continuous and stoppages of the line must be reduced to a minimum. The failure detecting system is electrically separate from the pinhole sheet rejection system which it monitors. " Pinhole signals " at the input to the main system are continuously sampled by the monitors, and delayed for the appropriate time before being compared with the " reject sheet " signal applied to the magnetic rolls by the rejection equipment. If the " reject sheet " signal does not occur at the correct instant, the monitor brings the stand-by channel into operation and gives an alarm.

In this installation the production line with driving units and operator's controls is installed on the mill floor, while the motor-generator sets, automatic contactor panels, magnetic amplifiers and electronic controls are installed in the basement, which is suitably ventilated.

The requirements and the overall design of the electrical equipment were specified by the consulting engineers, Messrs. McLellan and Partners.

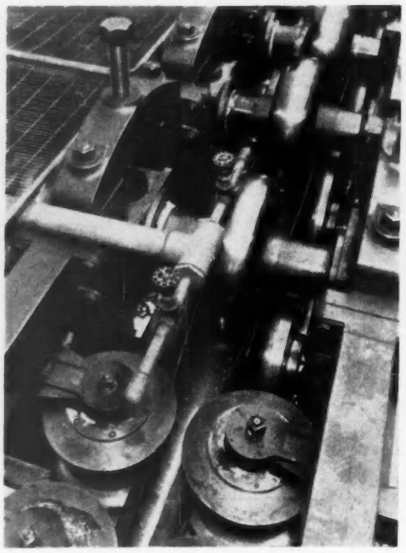


Fig. 2—Partially formed strip passing from vertical forming rolls to the horizontal rolls

Large Electric Resistance Welded Steel Tubes

A plant for making steel tubes up to 5½in diameter by the electric resistance welding process has been installed at the Wednesfield works of Tube Products, Ltd. Annealed and hydraulically tested tubes up to 60ft long will eventually be available from this plant. According to the size and wall thickness tubes are now being produced at speeds between 50ft and 120ft per minute.

SINCE plant for the manufacture of steel tubing by the electric resistance welding process was first introduced into this country in 1928 by Tube Products, Ltd., the use of this type of tube has extended to practically every branch of industry. Up till recently, however, the tubes have been available up to 4½in in diameter only, and to satisfy the demands of a wider field of industry a new plant capable of making tubes up to 5½in diameter and 0·280in thick, to the requirements of B.S.980, B.S.1717, B.S.1775, B.S.3059, B.S.806 by the electric resistance welding process has been installed at the Wednesfield works of Tube Products, Ltd. This plant is now making the large diameter tubes in lengths up to 60ft, and when a new furnace now being installed is completed, annealed and hydraulically tested tubes in the maximum sizes will be available. The whole of the plant is designed for continuous flow production and is being highly mechanised with roller conveyors and transfer equipment by which the tubes will be carried between all the finishing stages. For this plant a new building some 660ft long by 120ft wide has been laid down.

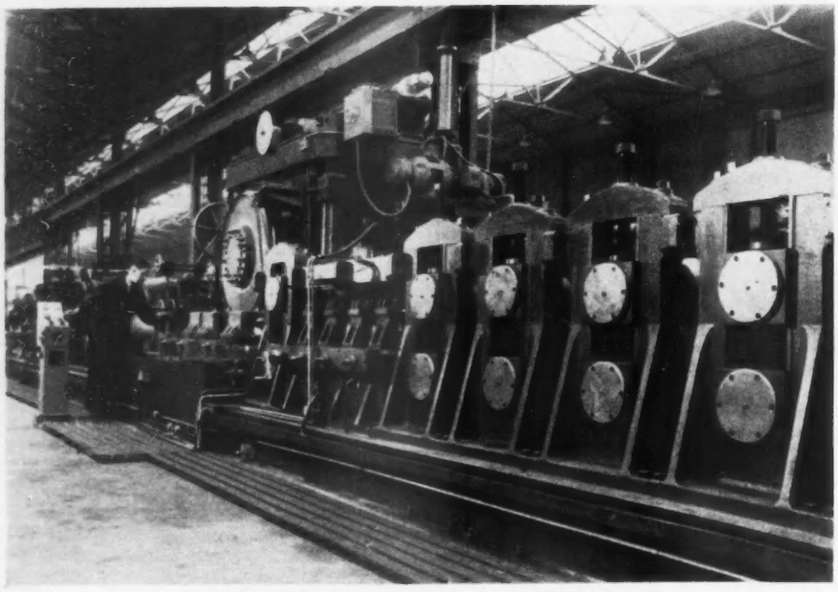
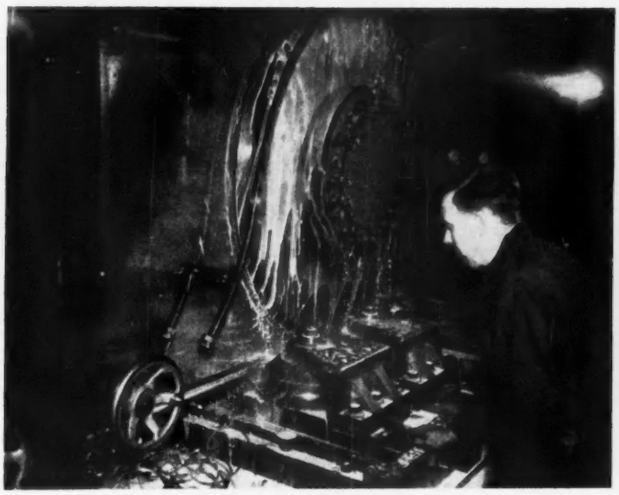


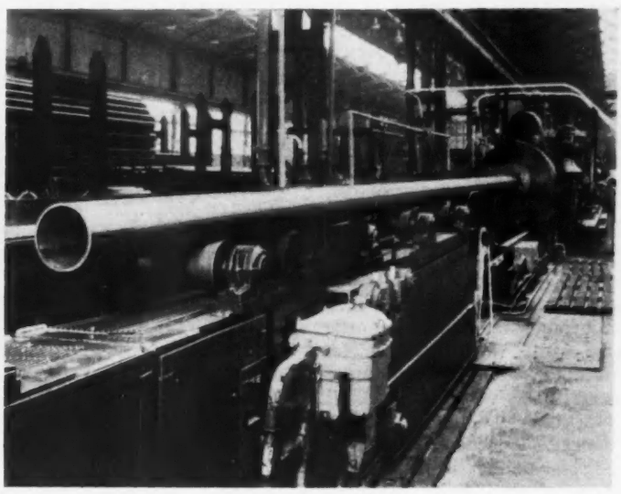
Fig. 1—Forming roll side of resistance welding machine

The actual tube making machine has been designed and constructed by the firm's own engineering staff, and it can be seen in the photographs we reproduce. Strip of the required gauge and slightly over-width is supplied to the machine in coil form. These coils are delivered to uncoiling stands near the feed end of the machine and from here they are drawn and wound on to larger spools or " spiders " which can hold up to 12 tons of strip each. As they pass out of the uncoiling station the ends of each coil are cropped square and butt welded to the trailing end of the preceding coil to form a continuous length on the spider. Two spiders are arranged on a turntable at the feed end of the machine and whilst one is being built up strip from the other is being drawn off into the machine. The spindle of each spider incorporates at one end a dog coupling which is connected to a drive at the side of the turntable during the coiling operation. Whilst strip is being drawn off the spider by the machine this drive is disengaged to permit free rotation.

At the beginning of the main machine line the strip first passes through a bank of levelling rolls and then along a feed table to a butt welding station where successive lengths of coils are welded together. A rotary disc shear next in line then trims the sides of the strip to the required width. his shear incorporates a chopper attachment for reducing the trimmings to readily manageable swarf. After then passing through a stand of vertical guide rolls the strip is drawn into the train of tube forming rolls shown in Fig. 1.

Initial forming is effected in seven stands of vertical rolls, which are driven through reduction gearing and universal shafts, and provide the main drive for the strip throughout the machine line. Depending upon the gauge of the strip and the diameter of the





Figs. 3 and 4—(Left) Rotary transformer resistance welding machine for tubes. The swarf at the left of the table is produced as the outside fin is shaved off. (Right) Tube passing on to run-out roller conveyor through the cutting-off machine

tubes being made the drive shafts are coupled to either a group or to all of these vertical roll stands. Drive to the reduction gear units of the vertical rolls is provided by two 100 h.p., 300 to 1500 r.p.m., variable speed motors, one at each end of a main shaft passing through the gear units. A third, similar motor coupled on the shaft normally functions as a standby, but it can be used to supplement the drive when heavy-gauge tubes are being made.

From the vertical roll stands the strip, now in the form of a " U " passes into a line of four horizontal roll stands (Fig. 2) which close the upper sides over to complete the tube form, and the tube then moves on to the table of the welding machine. This machine comprises a rotary transformer assembly, adjustable for height on a heavy column structure, and having electrode discs fixed on its end overhanging the welding table. The height of the transformer is adjusted through motor-driven shafting and worm gearing at the top of the machine to position the discs in accordance with the tube size being produced. The electrode discs are also interchangeable to suit the diameter of the tube being welded, and their profiles can be trimmed and cleaned *in situ* by the use of a tool mounted in a radiusing slide on the upper face of the machine housing. Normally the transformer is rotated by the pressure imparted through the electrodes on the moving tube, but for trimming purposes it can be driven by an auxiliary motor. A pair of horizontal rolls on the table below the centre line of the electrode hold the edges of the strip closed during the final continuous welding operation. Through the variable speed drive welding is effected at speeds varying from 50ft to 120ft per minute according to the size and thickness of the tube.

As the tubing leaves the welding table, Fig. 3, it is carried below a fixed tool which shaves off the small welding fin formed on the outside of the wall. The fin formed on the inside of the tube is also shaved off by a cutter supported in the tube by a bar anchored to a bracket in front of the horizontal closing rolls. After this trimming operation the continuous length of tubing passes through a spray cooling tunnel and then through five horizontal stands of final straightening and one set of vertical sizing rolls. If tubes of a special shape are required a stand of appropriately contoured rolls can be introduced on the machine at this stage.

The final operation carried out on the machine is the cutting of the continuous line of tubing into the required lengths, and this is carried out on the reciprocating rotary cutting machine shown in our illustration (Fig. 4). This machine runs freely on 10ft long bed ways. When the required length of tubing has passed through its centre it is automatically clamped to the tube and its cutters set in motion to sever the tube by the time it has reached the limit of its movement along the bed. The instant the machine is set in motion is determined by the operation of a micro-switch by a driven cam plate at the rear of the machine. This cam plate is rotated by a variable speed gear driven by a chain from the main driving shaft of the forming rolls, and in this way the cutting of the tubes to the required length is continuously and directly controlled by the rate at which they are formed and welded. Any length adjustments which are required are simply made by altering the speed of the variable speed gear output shaft on which the cam plate is mounted.

The micro-switch, through relays, actuates air valves. One of these valves admits air to the short stroke pneumatic cylinder in the bed of the parting-off machine and the ram of this cylinder accelerates the machine forwards a short distance at tube speed. This ram, in imparting an initial thrust to the stationary machine, relieves the tube of the load which would otherwise be imposed on the roll drive in accelerating such a heavy machine. A second pneumatic valve closes a set of jaws on the tube to lock it in the machine for the traversing movement. The feed lever for the machine cutters is extended to the rear, and as the forward movement starts this lever is carried on to a track set at an angle away from the machine. Progressive forwards movement of the machine pulls the lever along the track and swings its end outwards to feed the rotating cutters of the machine into the tube walls. At the end of the forwards movement of the machine when the tube length has been parted off the feed lever over-rides the guide track and swings back under spring loading to open the cutter jaws. At the same time a switch is contacted to open the gripping jaws and a pneumatic cylinder then comes into effect to return the machine along the bed to its position of rest ready for the next cutting operation.

When the tube lengths leave the parting-off station they pass on to a length of roller conveyors from which they are kicked by pawls to racks on one or other side of the line. Tubes which have to be heat treated are kicked on to a conveyer system on one side, and those which require only finishing operations on to transit racks on the other side. When the heat treatment furnace installation is completed a conveyor system will carry the tubes back to a roller system leading to the feed tunnel of a 312ft long roller hearth furnace. This electric furnace will have a controlled atmosphere and from it the tubes will pass out through a cooling tunnel.

A hydraulic pressure testing equipment which has been installed is designed to test tubes up to 60ft long at up to 6000 lb per square inch. The tubes gravitate in turn down a feed bank on to a series of pneumatic jacks below the machine and these jacks raise the tubes into position for sealing between the pressure testing heads. The tubes are first filled with suds from a low pressure high delivery centrifugal pump and then pressure is built up by a further supply of suds at 2000 lb per square inch from a hydraulic accumulator. Finally a high pressure reciprocating pump is used to build up pressures as required, up to a maximum of 6000 lb per square inch. The machine is quickly adjusted for varying lengths of tubes by resetting the back head along the bed and locking it into position with shear pins.

When it is required to face the ends of tubes they are transferred on roller conveyors to a group of three rotating cutter machines arranged in line on floor bed ways. These machines can be positioned along their beds to end-face tubes to the precise lengths specified. From this station the tubes are either transferred in bundles to a large storage area or directly to wagons on an adjacent rail loading bay in the corner of the building.

THROW-AWAY AIR FILTER UNITS.—A new form of air filter cell, 20in square by 2in thick, which has been introduced by Ozonair, Ltd., The Esplanade, Rochester, Kent, is designed to provide a cheap, efficient filtering unit which can be thrown away when laden with dirt. This cell is stated to have a high dust loading capacity and is filled with curled fibrous elements bonded together and impregnated with an adhesive. The non-corrosive filtering medium has a low air resistance and it is claimed that dust over 5 microns in size is trapped and held in the multiple channels of the element. Dust loading at twice the initial resistance is 1 lb per square foot of the surface area, i.e. a 20in square cell holds 2¼ lb of dust.

LETTERS AND LITERATURE

Letter to the Editor

We do not hold ourselves responsible for the opinions of our correspondents)

STANDARDS MAKING

SIR,—It was with feelings of emotion that I read your leading article of February 13 on standards making, for I am only just recovering my breath with astonishment at one of the latest masterpieces to emerge from the B.S.I. This "miracle" is none other than the revision of B.S.1574, dealing with the humble, and—one would have thought—innocuous subject of split cotter pins. Nothing so simple, however! The corps of genii which has no doubt argued, manœuvred one with the other, and to use your own expressive phrase been slowly jollied along by the secretary concerned, has achieved the momentous result of changing the nominal length from the original "over the head" to the new "under the head." This means that everyone who has been specifying split cotter pins in accordance with B.S.1574, which of course represented standard practice for many, many years before ever a B.S.S. was evolved for the beastly things, has now got to change.

A foreword to the revision airily states: "Since the standard was first issued in 1949 it has become general practice in many quarters to define the nominal length of split cotter pins as the distance from the underside of the eye to the extreme end of the short leg, and it is considered that the adoption of this method in the present Standard will help to avoid confusion."

Avoid confusion !! Because certain users decide to depart from established British custom the B.S.S. must be changed, and everyone else inconvenienced. The punishment for the perpetrators of this particular miracle should be made to fit the crime. Those who have been able to spare the time to live through the period of gestation should be made to make the alterations necessary to the millions of specifications, bills of materials and such like on which the objects of their long-protracted devotions are to be found.

Split cotter pins may seem a small subject to get angry about; but those of us who in our workshops and drawing offices are constantly striving to get done in one hour that which previously took two or three bitterly grudge the time spent in trying to keep pace with such changes in standards, and there are times when we have felt that the B.S.I., far from being a help to us, as it should be, is like an agglomerate of barnacles on the keel of productivity.

"M.I.MECH.E."

Bath, February 17, 1959.

Book Reviews

The British Railway Locomotive, 1803–1853. Compiled by G. F. WESTCOTT. Science Museum, South Kensington, S.W.7, and H.M. Stationery Office. Price 3s. 6d.

THIS booklet presents a brief pictorial history of the first fifty years of the British steam railway locomotive over the years 1803 up to 1853. There are in all fourteen pages of text, of which the first ten are given up to a general survey of developments as seen by the author, the remainder being devoted to brief notes descriptive of thirty-two plates illustrating the several locomotives singled out as representing important steps taken in the development of the British steam locomotive during the first fifty years of its existence. The numerous illustrations, which are well produced, are supported by short explanatory remarks already mentioned, which are particularly useful as indicating their origin.

Obviously, locomotives selected as representing advances made by successive designs would differ to a greater or lesser extent according to the views of the historian.

As cases in point, plates 15 and 16 may perhaps be taken, illustrating respectively Stephenson's 0–4–2 locomotive of 1834, built for the Stanhope and Tyne Railway, and the Tayleur 0–6–0 engine "Vulcan," for the Leicester and Swannington line, built at the Vulcan Foundry in 1835. The former engine was, it may be remarked, ante-dated by the 0–4–0 locomotives, "Samson" and "Goliath," which, on the advice of George Stephenson were, in 1833, modified by having a pair of wheels added at the rear end behind the firebox, thus becoming engines of the 0–4–2 type and the first to have six wheels combined with inside cylinders. Likewise, the Tayleur 0–6–0 locomotive was antedated by Stephenson's famous "Atlas" of February, 1834, the first 0–6–0 type engine ever built with inside cylinders, so being the prototype of one of the most generally useful locomotive types ever built for service on British railways.

Like Tayleur's engine, both these notable Stephenson designs were built for the Leicester and Swannington line. An important link in the history of the locomotive which is regrettably absent is an example of McConnell's excellent 2–2–2 passenger engines of the "Bloomer" type, built at Wolverton for the L.N.W.R. (Southern Division) period 1851–54. Perhaps, however, more serious note should be made of the locomotives illustrated by plates 1 and 2, described as showing "Trevithick's Coalbrookdale Locomotive" and "Trevithick's 0–4–0 Newcastle Locomotive" respectively. Referring to the former, this is presumably the engine fully discussed by E. A. Forward writing in THE ENGINEER of February 22, 1952, under the title "Links in the History of the Locomotive." If we are to accept this as being in fact a locomotive built by R. Trevithick at Coalbrookdale in 1803, which, according to Forward, we may, then what of the locomotive also ascribed to Trevithick, illustrated by plate 2? Here, it would seem, we are in some difficulty. Did Trevithick design and build this engine at Newcastle?

Referring to "Timothy Hackworth and the Locomotive," R. Young, 1923, there will be found on page 38 a drawing of an engine, an exact copy of plate 2, which is described as having been built at Newcastle by John Steel in 1804. The story is shortly as follows. It seems that Christopher Blackett, the proprietor of Wylam Colliery, having heard in 1803 of Trevithick's Penydarran locomotive experiments, entertained the idea of using steam power to convey coal from the mines for shipment. To this end, an arrangement was entered into with a firm, Winfield of Pipewell, Gateshead, to build a locomotive. Winfield is said to have had no experience of this kind of engineering, but had in his employ, a man, John Steel, reputed to be "a very clever fellow," who, it is stated, had been at Penydarran "where he had assisted in fitting the locomotive." The engine was, it is said, duly built, though never accepted by Blackett. It would appear from the full account of this episode, as given by Young, that some credence can be given to this story and, if such is the case, it may be that Trevithick's Penydarran engine resembled that shown by Plate 2 having been copied by Steel. Unfortunately, it is not quite so easy as that, because on referring to Clement Stretton, *The Locomotive and its Development*, 1892, we find on page 3 an illustration, "The First Locomotive 1803," described as Trevithick's Penydarran engine and which seems to be the same as the author's plate 1.

On the other hand, C. J. Bowen Cooke, *British Locomotives*, 1893, illustrates on page 5 an engine stated to represent Trevithick's 1803 engine, said to have done useful service at Penydarran and is shown to be like that illustrated by plate 2. Can it be that we are still uncertain as to the origin of what has long been considered to be the beginning of the world's locomotives? The author of this pictorial history of the locomotive throws no light on the matter, it being merely stated that "a Trevithick engine certainly ran on the Penydarran line in 1804, and it is conjectured that its design may have been based on that shown in the 1803 sketch." (Plate 1.)

Further references to the Penydarran and Newcastle locomotives will be found in the Trevithick Memorial Lecture, delivered by C. E. Inglis, F.R.S., before the Institution of Civil Engineers, and reprinted in THE ENGINEER of April 28 and May 5, 1933. The Penydarran locomotive is illustrated as being very like the author's plate 1, though it is stated that it "cannot be accepted as absolutely correct," and the Newcastle locomotive is shown to be like the illustration plate 2. In connection with the latter, it is said that it was "erected by John Steel, one of Trevithick's mechanics." In view of Young's account, this remark is not without interest.

Joints and Cracks in Concrete. By PETER L. CRITCHELL. Contractor's Record, Ltd., Lennox House, Norfolk Street, Strand, London, W.C.2. Price 40s.

TEMPERATURE and moisture movements in hardened concrete can result in bad cracking, if gaps or joints are not provided to prevent the development of excessively high stresses. The proper design and construction of these joints is obviously of the utmost importance, and yet there is no well-established practice. Engineers and architects have tended to treat joints as rather a small detail. Designs are extremely varied and are usually based on previous experience. This rather vague approach is due to the general lack of information concerning the actual *in situ* thermal and shrinkage movements, the effect of creep, &c. Mr. Critchell's book, the first to deal expressly with joints, is, therefore, of great interest. Joint design is governed to a large extent by the method of construction, and consequently the book is essentially practical in its approach. But the practice is firmly based on theoretical considerations and research work carried out by the author

and others. This book can be regarded as a complete summary of all that is known about joints and jointing materials.

The first part introduces the problem and discusses the movements to be accommodated. The author then defines two kinds of joint, the construction joint, which has to be made at the end of the working period and the functional joint, which is specially incorporated to take up movements. It is a pity that the problem of making clean and efficient construction joints is not dealt with more fully. Unsightly and badly positioned construction joints can mar the whole appearance of a structure and are the cause of much criticism of concrete as a building material. Very recent research has shown that the method of making this kind of joint, as described on page 38, is not the best. More information on construction joints and methods of disguising them would have been useful.

But the author has much to tell on the subject of functional joints. He surveys in detail the materials used in joint construction. A functional joint comprises a joint filler, a sealing compound, and for liquid-retaining structures, a water-bar. The function and required properties of each of these parts is discussed, together with notes on the different kinds available and factors governing their choice. Mr. Critchell then tackles the problem of joint design. No one joint is suitable for all work and for easy reference he considers three basic kinds of structure: buildings, paving slabs and water-retaining structures. Each structure has its own particular problems. Sketches of typical joint designs are given, their advantages discussed and criticisms and suggestions made. Further chapters consider the factors influencing the location, spacing and sizes of joints in the three basic types of structure. In addition, special attention is given to the problems of selecting suitable joints for bridges, block and brick construction, prefabricated work and concrete pipes. But no matter how carefully joints are designed and constructed, faults can develop. The common defects with suitable preventive measures are listed and the importance of proper inspection and maintenance during the life of a structure strongly emphasised.

Other chapters cover methods of testing the quality of joint materials and the additional problems likely to be met with in the design and treatment of joints in countries overseas. The book contains a useful index and is well illustrated. Mr. Critchell has used his own considerable experience of the subject, together with a great deal of published work, referred to in an excellent bibliography, to produce a reference book which should commend itself to all concerned with the design and construction of reinforced concrete structures.

Technische Laufwerke einschliesslich Uhren. By FR. ASSMUS. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price DM.36.

THE author is director of the German Federal College of Precision Engineering at Furtwangen. His aim throughout this book has been to present a balanced treatise, combining and enriching the theoretical approach with practical examples. The fundamental mathematical and mechanical basis for design and calculation of all kinds of mechanisms, ranging from single components to complex assemblies, is very thoroughly dealt with, but those whose interest and training may be mainly in the sphere of practical applications and uses of mechanisms will find at every stage clear diagrams, photographs and concise descriptions of the widest conceivable range of actual engineering mechanisms for all industrial purposes.

Horological gearing and escapement design are subjects on which the literature available in any language has been extremely meagre. Hitherto, the works of G. A. Berner (*Notes for the Horologist*), W. O. Davis (*Gears for Small Mechanisms*) and a few others have formed the basis for design and teaching. The present book provides a very welcome addition to the existing literature, and while it will certainly not have been the author's intention to oust any of the few well-known works on the subject, all of which occupy a respected place, it must be said that nowhere before has such a fully comprehensive guide been available.

The chapter headings are as follows: "Gearing and Gear Trains," "Design and Gear Tooth Form," "Frictional Losses and Bearing Design," "Driving Forces and Sources of Power," "Indicating and Registering Mechanisms," "Regulators and Horological Escapements," and "Horological Alarms and Chime Mechanisms."

Although difficulties of translation will inevitably limit its usefulness for many readers, the book is very copiously provided with clear illustrations, mainly diagrammatic (its 272 pages contain 273 illustrations), and these help considerably in overcoming this obstacle and making the text generally understandable. Indeed, those readers who possess something of a working knowledge of the language may even find that the book provides a valuable incidental means to increase their technical vocabulary within this sphere of precision engineering.

Books Received

Time Measurement. Part 1. Fourth edition. By F. A. B. Ward. The Science Museum, South Kensington, London, S.W.7. Price 5s. 6d.

Dynamical Analogies. Second edition. By H. F. Olson. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 51s.

The Structure of the Atom: A New Theory. By H. Melville Dowsett. Published by the Author at Greatford Hall, Greatford, Near Stamford, Lincs. Price not stated.

Progress in Non-Destructive Testing. Vol. 1. Edited by E. G. Stanford and J. H. Fearon. Heywood and Co., Ltd., Ingersoll House, 9, Kingsway, London, W.C.2. Price 60s.

Chemical Engineering Practice: Vol. 6, Fluid Systems 2. Edited by H. W. Cremer. Butterworth's Scientific Publications, 4 and 5, Bell Yard, London, W.C.2. Price 95s.

Elementary Telecommunications Examination Guide. Second edition. By W. T. Perkins. George Newnes, Ltd., Tower House, Southampton Street, London, W.C.2. Price 17s. 6d.

Transactions (Seventy-fourth Session, 1957–58) of the North East Coast Institution of Engineers and Shipbuilders. Published by the Institution, Bolbec Hall, Newcastle upon Tyne.

Hydrology for Engineers. By R. K. Linsley, M. A. Kohler and J. L. Paulhus. McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, London, E.C.4. Price 62s.

Manual of Civil Engineering Plant and Equipment 1958. Compiled by John M. Paxton. Contractor's Record, Ltd., Lennox House, Norfolk Street, London, W.C.2. Price 130s.

Technical Drawing. Fourth edition. By F. E. Giesecke, A. Mitchell and H. C. Spencer. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 52s. 6d.

Dictionary of Civil Engineering and Construction Machinery and Equipment. By Herbert Bucksch. Contractor's Record, Ltd., Lennox House, Norfolk Street, Strand, London, W.C.2. Price 65s.

The Performance and Design of Alternating Current Machines. Third edition. By M. G. Say, Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 37s. 6d.

Obituary

T. L. ECKERSLEY

WE regret to record the death on February 16 of T. L. Eckersley, whose work with Marconi's Wireless Telegraph Company, Ltd., on the propagation of radio waves has been recognised internationally as of fundamental importance in the development of communication and broadcast systems.

Thomas Lydwell Eckersley, a grandson of T. H. Huxley, was born in 1886 and educated at Bedales School. It was during his service in the first world war with the Royal Engineers in Egypt and Salonika that he made his first important experiments on night effect and coastal refraction phenomena, an understanding of both being essential to the use of radio direction finding in navigation. On joining the research staff of the Marconi company in 1919, he began the work on the resistance of transmitting aerials which, when published in 1922, earned the award of the Duddell Premium of the Institution of Electrical Engineers. Later, he analysed the findings of the research team sent to Australia by the Marconi company to study long-wave propagation and the results were embodied in a classic paper, of which he was a joint author, entitled "Report on Measurements Made on Signal Strength at Great Distances During 1922 and 1923 by an Expedition Sent to Australia." The paper was published in the *Journal of the Institution of Electrical Engineers*, Volume 63, October, 1925, page 933.

In connection with the Marconi–Franklin beam system, Eckersley turned his attention to the propagation of high-frequency electromagnetic waves, and between 1924 and 1939 directed a research team by which many pioneer ionospheric investigations were conducted. His work on the basis for predicting the performance of high-frequency radio services, published in later I.E.E. papers, was confirmed brilliantly in practice.

Eckersley applied the phase integral method both to the magneto-ionic theory of ionospheric propagation and to the problem of the effect of the earth's resistivity on the diffraction of radio waves round the earth, communicating his work in several papers to the Royal Society, of which he was made a Fellow in March, 1938. These researches were extended to the tropospheric propagation of very high frequencies and are to a great extent the basis of present-day systems of forward scatter transmission. In 1940 Eckersley joined the staff of the Air Ministry for secret work and in 1942 became Chief Scientific Adviser to the Interservices Ionosphere Bureau, established at the Marconi Research and Development Laboratories at Great Baddow. His contributions to radar techniques were important and his theories were of value in improving the radar detection of submarines when masked by sea scatter.

Eckersley was obliged by ill health to retire from his post as senior research engineer with the Marconi company in 1946 but continued as a consultant to the company. He was awarded a Fellowship of the American Institution of Radio Engineers in the same year; the citation stated, *inter alia*: "Both his approach to the problem from the standpoint of practical communications and his invention of mathematical tools useful in the computation of radiated fields are achievements of lasting value, acclaimed by the whole radio world and form a monument of which he may be justly proud." In 1951 he received the Faraday Medal for achievements in radio research, particularly for outstanding contributions to the theory and practice of radio wave propagation.

Why Restrict Output?

By ANTONY VICKERS, B.Sc., M.I.Mech.E.

In this article the author points out that for the last year and more output in this country and Western Europe has been declining, but that in Russia and Eastern Europe it rose rapidly. He asks why it should seem essential that the output of this, or any other country should be restricted and concludes that it is only outdated habits and rigidities in our monetary system that make it appear so.

IN times like the present, when there is no shortage of manpower, materials or machines, the question is seldom asked or answered as to why output should be restricted, both by capital and labour. Nor is there any lack of demand for a higher standard of living, which can only result from greater output. Thus engineers, who have been so largely responsible, since the Industrial Revolution, for devising the means for increasing production have good reason to raise this vital question.

During the war, and for years after, every possible effort was made to increase production. Productivity teams of industrial engineers and trade unionists visited the United States to learn how productivity might be increased, and this work has been energetically pursued by the British Productivity Council. But recently a change has come about, as for example in our great coal industry, where the N.C.B. Chairman, as reported in THE ENGINEER of January 9, 1959, said :

" Throughout last year the decline in coal consumption, which had started in 1957, continued. The coal mining industry, therefore, which for many years had striven to increase its output, was compelled by the turn of events to take steps to limit production."

What turn of events should cause production to be limited ; for 5,000,000 tons a year of steel capacity, for example, to remain idle ?

In its first review for January, 1959, the National Institute Economic Review, reporting on the British economy, states that, despite all of the capital investment :

" Industrial production is now no higher than in 1955, and there is enough unused capacity and labour to permit a rise of 10 to 15 per cent in two years."

This means that if this wasted capacity of manpower, machines and material were effectively employed, the nation's output would be increased by £2500 to £4000 million a year, representing a substantial rise in the standard of living.

In Britain we are told that our prosperity is greatly influenced by the economic health of the United States, the economic leader of the free nations. Last year American taxpayers paid their farmers 614 million dollars NOT to produce a variety of crops which the U.S. Department of Agriculture estimated at: 175 million bushels of wheat ; 225 million bushels of corn ; 2,000,000 bales of cotton ; 600 million pounds of rice ; 93,000,000 lbs of tobacco. How healthy or convincing is such economic practice in a world where Communism is seeking every means to defeat Capitalism ?

Turning to Europe, the Bulletin of the United Nations Economic Commission, as reported in the *Sunday Times* of January 4, under the headlines of " Soviet Output Jumps Ahead. West Europe Standstill " says :

" Industrial output rose rapidly in Russia and the Eastern European Communist countries in the first nine months of last year . . . . In sharp distinction to this was the general picture of the Western European economic scene." " By the middle of 1958," the Bulletin reports, " the levelling off in the rate of industrial production had spread to the majority of Western European countries, and in some instances there was even a downturn."

Can it really be doubted, if the free nations continue to restrict their output, that it will only be a matter of time, and not so long at that, before Russia and the Communist countries win, not only the economic war, but also the political one? There are, of course, some who are quite content that all is as well as can be expected. There are others who feel that their job is to get on with their engineering and leave well alone. There are, however, an increasing number who take the broader view and realise that there is some flaw in the economic system of the free nations which compels output to be limited, except in times of shortage, and thereby to suffer a severe and, perhaps, fatal handicap with the Communist nations. Fortunately, it seems that economic thinking in financial quarters is beginning to realise that the monetary system has not kept up with modern production and the leader of *The Financial Times* said on September 4, 1958 :

" The more readily and quickly the monetary system abandons its outdated habits and rigidities, the more clearly the need for new policies will stand out."

What new policies ? Well, the Chairman of Barclay's Bank, Ltd., gave a clue in an article published in the *Sunday Times* of July 13, 1958 :

" . . . but nevertheless I think the Chancellor probably recognises the importance of demand being allowed to match the increased production, which he is doing his best to stimulate by other means."

Demand, however, is rather a loose term, and there is a wide gap between the " desire to buy " and effective demand, which means purchasing power or the ability to buy. In the ultimate, purchasing power is almost entirely distributed through salaries and wages, and this is where a problem arises. In these days of automation and high investment per individual employed, it is not unusual for a man to have £250,000 of capital equipment behind him, and thereby to produce goods worth fifty times his earnings. Thus, despite the interest payable on the capital, the capacity to produce exceeds the purchasing power distributed. In much of industry the capital per individual employed is considerably less but, nevertheless, the same principle applies and, to enable demand to match increased production, additional purchasing power should be introduced into the economic system, and particularly by effective Government action. This would mean not only stimulating the right amount of consumer demand, but also by capital investment of benefit to the nation as a whole, such as roads, railways, defence equipment, educational establishments, hospitals and so forth, strictly depending on the production capacity available—part, perhaps, of the 10 to 15 per cent of unused capacity at the present time. It is no solution simply to raise salaries and wages merely because the Cost of Living Index has again risen and the pound buys correspondingly less.

What is the cost and where is the source of this additional purchasing power or money that is needed to enable the unused capacity of manpower, materials and machinery to be effectively used ? In April, 1957, the then Chancellor of the Exchequer appointed the Radcliffe Committee to investigate the working of monetary and credit policy in Britain, and it is earnestly hoped that strong recommendations may follow to replace the present " outdated habits and rigidities " by a monetary system in keeping with the requirements of modern production and trade. As Sir Winston Churchill has so often emphasised, in order to see more clearly into the future it is necessary to study the past. What lessons might be learned, then, from that great American President, Abraham Lincoln, on the principles of monetary policy ? The following brief extract from the Library of Congress Legislative Reference Service in Washington says much :

" Money is the creature of law and the creation of the original issue of money should be maintained as exclusive monopoly of National Government . . . ."

" Money possesses no value to the State other than that given to it by circulation . . . ."

" Government possessing the power to create and issue currency and credit as money and enjoying the right to withdraw both currency and credit from circulation by taxation and otherwise, need not and should not borrow capital at interest as a means of financing governmental work and public enterprise. The Government should create issue, and circulate all the currency and credit needed to satisfy the spending power of the Government and the buying power of consumers. The privilege of creating and issuing money is not only the supreme prerogative of Government, but it is the Government's greatest creative opportunity . . . . "

" The taxpayers will be saved immense sums of interest, discounts and exchanges. The financing of all public enterprise, the maintenance of stable government and ordered progress, and the conduct of the Treasury will become matters of practical administration."

And, looking to the future in Russia, where the monetary system is designed to permit full and expanding production, how shall we measure up in ten years' time ? Shall we, and the other Western nations, continue to restrict output or shall we dare to allow production to expand by matching it with increasing demand ?

ACID AND ALKALI RESISTANT CEMENT.—A new cement marketed by J. H. Sankey and Son, Ltd., Ilford, Essex, is claimed permanently to withstand the chemical action of both acids and alkalis. It is called " Alcuma," and is composed of polyester resins, combined with inert fillers, and blended to produce an impermeable cement. It is supplied in the form of a powder and solution, and when these are mixed the cement has a soft putty-like consistency which makes it easy to apply. The cement sets to a very close, stone-hard texture : it is suitable for bedding and jointing, or pointing, vitrified tiles and bricks in the construction of acid and alkali resisting floors, benches, tanks, and brickwork, and it can also be used for jointing and sealing pipes carrying acids and alkalis.

New Digital Computer Techniques

A series of specialist discussion meetings on new techniques in digital computers was held by the Measurement and Control Section of the Institution of Electrical Engineers in London on February 16 and 17. There were six sessions at which contributions were presented and discussed on the subjects of character recognition, peripheral equipment, low-temperature storage and switching devices, and special aspects of logical design. Some aspects of these techniques as described in the papers are summarised below.

THE proceedings of the meeting were opened on February 16 by Mr. S. E. Goodall, president of the Institution, who said that 460 delegates had registered, including representatives from the U.S.A. and various European countries.

An introductory lecture to the first session, on character recognition, was given by C. E. G. Bailey (Solartron Electronic Business Machines, Ltd.). After outlining early approaches to the problems of character recognition, he described how a nearly morphological system had now been patented for the reading of handwriting. In the system a horizontal sawtooth scan is interrupted when it strikes the left- and the right-hand boundaries of the character. The positions of these intercepts may be regarded as a contour with respect to the vertical component of the scan. Sharp discontinuities occur with various figures ; the presence and sign of these discontinuities constitute a code for the figure, which is evaluated by means of a matrix store. To be readable automatically the handwritten figure must fulfil a certain specification, which imposes some limits—not very severe—on the writer.

Even fewer limits are imposed by the figure specification developed by Dr. Dimond, in which the intersection of the figure with any of seven construction lines is observed. Dimond developed his specification for use with conductive ink, but an early application by Naumberg points the way to performing this operation optically. Apart from this proposal, the major development effort has been concentrated on optical scanning.

Within the past few years, however, a great deal of work has been done in America on the recognition of characters printed in magnetically permeable ink. The basis of this method is to read the effective area of magnetic ink under a horizontally narrow head-gap covering the figure from top to bottom.

The present state of the art was illustrated by reference to the Electronic Reading Automaton (THE ENGINEER, March 15, 1957), which is now in the production stage. This machine is designed to read typewriting or ganged printing. Investigations are being made into the possibility of replacing the permanent wiring in the ERA logic by a coded set of signals on, say, a magnetic drum store, which should result in the appropriate matching patterns being offered serially or simultaneously to the filled store. The first applications are to continuous-roll reading. To minimise the on-line loading time of the rolls, a feed mechanism has been devised, taking preloaded cassettes. When a cassette is inserted, rollers, followed by a vacuum feed, pull the paper past the scanning position, and the roll is automatically spooled up.

The spacing between lines of print varies in practice between one originating machine and another. The smoothed output of the vertical misregistration signal is accordingly taken to a servo system which accelerates or retards the paper feed accordingly.

Automatic Recognition of Patterns

Two papers dealt with the recognition of patterns. A contribution by Drs. R. L. Grimsdale, F. H. Sumner, C. J. Tunis and T. Kilburn, all of the electrical engineering laboratories, Manchester University, pointed out some limitations of character-recognition devices and described a method for recognising patterns as assemblies of lines and curves. The pattern is presented to a flying-spot scanner which transfers it to the high-speed store of the computer, where it is represented on a raster of 40×64 points. The pattern is examined by a programmed scan which results in its being divided into a number of parts or " groups." The groups are described in terms of their length, position, slope or curvature, and are then assembled into the natural pattern divisions.

The complete pattern is described by a " statement," which gives a list of these natural divisions and the way in which they are joined. The statement is compared with a set of statements stored within the machine ; this comparison makes use of a scoring system, and the name of the pattern whose statement gives the greatest score is printed out. When there is confusion, this is indicated by the machine and the relative probabilities of the possible patterns are printed out.

If the machine is presented with a new pattern, it will indicate that it does not know that pattern, and the name of the pattern may then be supplied to the machine by the operator. On subsequent occasions the machine will recognise this pattern, even though it is drawn afresh by hand. This ability to learn is an important feature of the system. The machine builds up its list of standard patterns in this manner and is thus universal ; it is in no way restricted to any particular type face or style.

A method of pattern recognition by automatic analogue apparatus was discussed by Dr. W. K. Taylor of the department of electrical engineering, University College, London, based on the use of photosensitive transducers to sample light intensity distribution. Recognition of patterns is the equivalent to classification of sets of computer output signals. The author drew attention to the fact that if a letter, for example, is composed of dots, the absence of certain dots will not confuse a human operator although it would prevent recognition by a machine. The simplest assumption which can be made to account for this phenomenon is that all dots have an equally effective influence on the classification, irrespective of the actual number present. This assumption requires that the principle of superposition should apply and that the signals should be added in a linear analogue network rather than made to open and close the gates of a switching network.

Two contributions were concerned with recognition of numerals. Dr. Ing. W. Dietrich (Standard Elektrik Lorenz A.G.) described an optical method of scanning typewritten numbers with precautions against misidentification as a result of smudging of the paper or characters. A contour following system was described by Drs. W. Sprick and K. Ganzhorn (I.B.M. Deutschland G.m.b.H.). Arabic numerals present the main amount of recognition information at both sides as seen horizontally from right and left. By means of a contour follower it is possible to find voltage functions analogous to both sides, e.g. if the numeral is scanned from top to bottom. The characteristic points are then detected by differentiating these functions and transforming them into a characteristic differential pulse pattern.

The contour follower is simulated by a circuit arrangement which scans the numeral in horizontal lines from the top to the bottom, as in the common television system. It converts the pattern of the video pulses to two patterns of pulses, the envelopes of which are equal to the right- and left-hand sides of the numeral. The conversion from video pulses to both patterns of envelope pulses is obtained by clipping the video pulses at the momentary value of two sawtooth voltages, one being in synchronism and the other reversed with regard to the scanning voltage.

The differential quotient is obtained by means of an *RC* circuit, with a small time-constant, which delivers sufficiently evaluable differential patterns. The comparison—or, more generally, the evaluation—circuit comprises an arrangement of criteria detectors, storage units which store the criteria during the scanning procedure and a co-ordination logic. This logic performs the connection between the criteria and the output lines associated with the numerals 0–9 by means of the reference-pulse patterns, realised by " yes " and " no " connections in a co-ordination matrix.

Peripheral Equipment

Ten contributions were presented to the second session of the meeting, dealing with peripheral equipment. Several of them described high-speed printing equipment, among which was a high-speed line printer using optical methods. The authors, G. G. Scarrott and J. A. Freer (Ferranti, Ltd.), emphasised the need for a fast output printer if the best value is to be obtained from a computer, particularly in a data processing system. In the equipment described, an optical method has been adopted which allows the complete elimination of reciprocating mechanisms, so that the mechanical design can be very simple. A second feature of the design is that complicated electronic components and precise analogue-control waveforms have been avoided.

The essence of the method of producing a line of print is that master characters are illuminated as required and their images are projected by a lens on to a moving photographic recording medium. The master characters are opaque on the surface of a continuously rotating transparent cylinder. Positions are defined along the axis of this cylinder to correspond with each character position within a printed line. In all these positions the full set of available characters is inscribed round the circumference of the cylinder.

One of the limits to the speed of a photographic device is the exposure required by the sensitive material. Because the master characters are moving, it would normally be possible to allow only very short exposure or

a blurred image would result. To compensate for this motion and to "maximise" the exposure, concave cylindrical surfaces are cut in the drum. Their curvature is such that when a character is projected it is apparently on the axis of rotation and therefore stationary.

Simple unfocused cathode-ray tubes are used as sources of light. One tube is provided for every character position within a line, and a system of light guides directs the light from the face of each tube to illuminate one master character position. A ferrite-core matrix controls the sequence of turning on light sources. The rectangular matrix has a row for each of the available characters and a column for each character position in a line.

Data specifying one line of print is decoded into the rows, characters going to successive columns. Each column then contains only one core in the "set" state. The line of print is formed during one revolution of the master cylinder. As each row of characters on the cylinder comes opposite the row of light guides, a full "reset" current is passed through the corresponding row of the matrix. In being reset, any core which was previously in the set state emits a voltage pulse. This pulse is used to turn on the light source in the corresponding column for an accurately defined time. In this way the line of print is built up in the order in which characters pass the light sources, no matter in what columns these characters occur.

Since different characters are exposed at different times, it is necessary for the recording medium to be effectively stationary during the printing operation. If the medium were to be literally stationary, an intermittent motion would be necessary. To avoid this, a square prism is used to deflect the image formed by the projection lens. The prism rotates in synchronism with the master drum and causes an image displacement proportional to its angular rotation. Thus the photosensitive material may move at constant velocity, while the displacement of images ensures that all characters are, in fact, printed in a straight line.

In the same session, a high-speed stylus printing system was described by J. H. Lucas (Whyteleafe Research Establishment, International Computers and Tabulators, Ltd.). This system, suitable for use with magnetic tape or punched cards, offers the facility of defining the shape of a character by a train of electrical impulses instead of by the actual configuration of the character on the face of a type-wheel or type-bar. This enables characters to be selected by a switching operation, which can be either electromechanical or electronic, instead of by the physical movement of the type carrier. The combination of stylus printing and electronic switching is claimed to offer the prospect of providing a reliable high-speed line-printer capable of meeting the requirements of high-speed data-processing systems, particularly for commercial applications. For use with magnetic tape an electronic type of switching matrix which makes use of subminiature gas-filled triodes is used. A ferrite-core buffer store and character generator for use with the stylus printer were described by A. H. Ellson of the same research establishment.

Low Temperature Storage and Switching Devices

The fourth session of the meeting opened with a lecture by Dr. D. R. Young (I.B.M. Research Center, New York) in which reference was made to a memory device using thin superconducting lead films which operated in the millimicrosecond region, thus demonstrating the potential high speed of operation of superconducting devices. This has led to further development of a wire-wound switching device called a "cryotron" which used magnetic control of the state of a superconducting wire. The original cryotron, described by Buck in 1956, operated in the kilocycles-per-second region, and work is now proceeding on a high-speed cryotron using thin superconducting films and named the "planar cryotron."

Dr. K. A. G. Mendlessohn (Reader in Physics, University of Oxford), in a contribution on the superconduction of switching and storage, said that the main characteristic of the phenomenon was complete loss of resistivity, which had been demonstrated by maintaining a persistent current in a simple ring for over a year without measurable decay. The disappearance of resistivity occurs, for a pure metal, discontinuously at a given temperature, the transition point, T_c, being characteristic of the metal and ranging from 0·5 deg. to 10 deg. K for pure metals. The highest T_c so far has been found in a compound, niobium-nitride (about 15 deg. K), and for a number of reasons it appears at present unlikely that appreciably higher values of T_c can be obtained. This means that devices embodying superconductors require the use of liquid helium.

The least complication is encountered by working at 4·2 deg. K (the boiling point of helium), or just above it. The critical point is at 5·2 deg. K, and temperatures down to about 1 deg. K can be obtained by pumping off the vapour.

Only certain metals, none of them monovalent, have been found superconductive. Of these, only those whose T_c is not too low are, at the present state of cryogenics, suitable for application in switching devices. They are: niobium (9·2 deg. K), lead (7·2 deg. K), vanadium (5·1 deg. K), tantalum (4·5 deg. K), lanthanum (4·4 deg. K), mercury (4·1 deg. K), tin (3·7 deg. K) indium (3·4 deg. K) and thallium (2·4 deg. K). In the present state of knowledge the use of alloys or compounds is inadvisable, and lanthanum, mercury and thallium have undesirable properties. Niobium, vanadium and tantalum present difficulties, which leaves lead, tin and indium, of which only lead has a T_c value above 4·2 deg. K.

Superconductive switching devices generally work through the quenching of superconductivity by an external field, usually produced by another superconductor. The transition between the superconductive and normal states is attended by thermal and electrodynamic effects which tend to reduce the speed of switching. Both of them are volume effects, and it is therefore necessary to use fine wires or thin films for fast switching. For the above-mentioned reason, most experiments in the latter field have been made with lead, and switching speeds of 25 millimicroseconds have been reported. Circuits are usually so arranged that the switch is open in the normal state and closed in the super-conductive state. Moreover, the use of persistent currents allows the construction of excellent memory devices for large storage devices to which access can be rapid. If to these features we add compactness and negligible power dissipation, the advantages may easily outweigh the use of liquid helium.

Further information on superconducting storage devices was given by Dr. J. M. Lock (Royal Radar Research Establishment), who described how left- and right-handed persistent currents in a superconducting circuit can be used as the two states of an information storage device, and to switch it from one state to the other, use is made of the fact that, if the circuit is made to carry a large enough "critical" current in either direction, superconductivity is destroyed, the normal resistance returns, and the current decays. These changes can be carried out by means of a drive wire linked inductively with the superconducting circuit, and, in fact, positive and negative drive-current pulses produce persistent currents of opposite sense.

The speed with which such a device can be switched from one state to the other depends, among other things, on the rate at which the supercurrent decays when normal resistance is restored. The behaviour of thin films of lead and tin has been studied at temperatures down to about 1·5 deg. K, and persistent-current elements have been made which can be switched from one state to the other in less than 50 millimicroseconds.

It is considered that it would be feasible to use thin-film storage elements as the basis of a large computer memory containing as many as 10^7 bits, and with a random access time of less than 50 millimicroseconds.

The final session of the meeting was devoted to a discussion of some special aspects of computer design, a subject on which seven papers were presented. Introducing the session, Dr. M. V. Wilkes (Director of the university mathematics laboratory, Cambridge) defined "logical design" as meaning the overall design of a digital computer, or computing system, regarded as an assembly of switching and storage elements together with various items of peripheral equipment. "Systems design" would perhaps be a better term, but "logical design" is by now firmly established as the accepted usage.

While responsibility for logical design is included among the other responsibilities of the design engineer, it has been noticeable for some time that certain trends in computer development are tending to divorce logical design to some extent from engineering design. One example is the provision of "building blocks" which can be interconnected in any desired manner provided that certain loading rules are satisfied.

Developments in the engineering design of basic components influence the economic aspects of logical design, and it is important to re-examine from time to time the extent to which formerly accepted principles are still valid. Two contexts in which this seems necessary at the present time relate to the provision of "dead" or non-erasable storage, and to the importance which should be attached to the efficiency with which floating arithmetic operations are performed in machines intended for scientific calculation. The advent of time sharing has also raised some interesting points, particularly in relation to the relative economics of on-line and off-line equipment in business data-processing systems.

Contributions to this session of the meeting dealt with a system of control for a fast computer, parallel addition in digital computers, transistor logic using current switching and routing techniques (with its application to a fast "carry" propagation adder), and design principles of the neuron and resonant-circuit logical elements.

Multi-Hole Extrusions.—We are informed that High Duty Alloys, Ltd., has developed stress carrying multi-hole extruded sections which will assist designers where a heat exchanger forms part of the structure. The sections are of high-strength Hiduminium alloy possessing good resistance to corrosion and a wide variety of cooling or heating media can be circulated.

M.V. "Colchester"

NEW CARGO VESSEL FOR THE HARWICH-ANTWERP SERVICES

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

IN a former article* the M.V. "Isle of Ely," built for the Harwich-Rotterdam cargo services of the Eastern Region of British Railways, was described in some detail, and now her sister ship, "Colchester," has taken up her duties on the Harwich-Antwerp service. Since the time when the railways obtained Parliamentary powers to maintain steamer sailings, the then Great Eastern Railway instituted a service of well-equipped passenger steamers on a service between Harwich and Antwerp. The last of these was the appropriately named "Antwerp" (Fig. 1), she being built in 1920, with a sister ship, "Bruges," which unfortunately was lost in 1940 off the French coast. These were vessels propelled by single reduction geared turbines which gave them a speed of 21 knots. These two vessels maintained regular sailings which were very popular until war broke out in 1939, and the service was suspended in 1940.

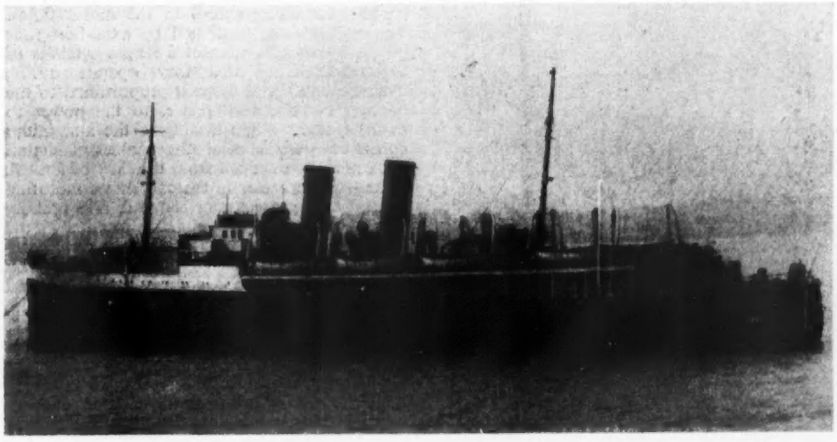


Fig. 1—S.S. "Antwerp" which maintained a passenger service Harwich-Antwerp before the second world war

"Antwerp" was taken over by the Admiralty, and, although she survived the war, she never again plied on her old railway sailings. In order to restore the service, two steamers of the former Great Central Railway's fleet were transferred to Harwich in 1946, the two steamers being "Accrington" and "Dewsbury," both well on in years, having been built at the yard of Earle's Shipbuilding Company, of Hull, in 1920. These steamers operated a regular passenger service between Parkeston Quay, Harwich, and the Quai d'Herbouville, Antwerp, until 1951, when "Accrington" went to the breakers, and "Dewsbury" (Fig. 2) was converted to a cargo steamer with, however, good accommodation for twelve passengers, her sailings being on Mondays and Thursdays. The railway people speak of her as "this very old lady, this proud dowager," and she is certainly one with a very varied career, for in addition to her normal duties for the Great Central, she did a spell on the Hull-Zeebrugge service, and during the war she was a rescue ship with Atlantic convoys, standing up well to all weather conditions in the North Atlantic, across which she made a passage from the Clyde to Halifax (Nova Scotia), while she also was found at Gibraltar, testifying to the sturdiness of the old railway steamers. And now her days are numbered and she will probably soon share the fate of the "Sheringham," illustrated in the previous article, for the latter arrived in Antwerp on December 10 last, to be broken up in Belgium.

And so the passenger service to Antwerp has come to an end, and the good-looking steamers are replaced by motor vessels which, even if of less pleasing lines, are certainly more efficient and better suited to their work.

The new M.V. "Colchester" was launched at the Goole Shipbuilding and Repairing Company's yard at Goole, Yorkshire, on October 14, by Mrs. White, wife of the Assistant General Manager of the Eastern Region, and she made her maiden voyage to Antwerp on February 2. The many innovations made in her and her sister have enabled sailings to be increased to three a week in each direction with the one vessel. The three months' experience of the "Isle of Ely" has not led to any modifications in the newer vessel, and as her dimensions and general layout are the same as those of her sister it is not necessary to repeat them, but the advent of "Colchester" completes the story of the modernisation of the cargo services between Harwich and the Continent.

It is of interest to note that when the "Dewsbury" is disposed of, there will be only one pre-war vessel on the Harwich station, and she has been so thoroughly modernised as to be almost entitled to rank as a new vessel, one that is preferred by some to her later sisters.

Fig. 2—S.S. "Dewsbury," Parkeston Quay, Harwich

* THE ENGINEER, December 5, 1958, page 892.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GIRDER BRIDGES. PART 1: MATERIALS, WORKMANSHIP, PROTECTION AGAINST ATMOSPHERIC CORROSION. PART 2: WEIGHING AND SHIPPING, ERECTION

No. 153. Price 6s. This specification, first issued in 1922 (B.S. 153, Girder Bridges) has been revised and re-issued twice. In consequence of modifications in the loading requirements for railways and highway bridges and of advances in experimental research and in design, a further revision became necessary, and agreement having been reached on loading requirements, it was considered advantageous to precede the present general revision with the issue in 1954 of Part 3A—"Loads." The remaining parts, which have now been extensively revised, have been re-grouped and issued as two separate publications. The first publication includes Part 1 dealing with materials, workmanship and protection against atmospheric corrosion, and Part 2 covering weighing, shipping and erection. The second publication contains Part 3B, Stresses, and Part 4, Design and Construction; and it is hoped eventually to incorporate in it Part 3A, at present published separately.

In this revision design and fabrication procedure have been brought up to date with a view to ensuring maximum efficiency in the finished structure. The specification is intended primarily to apply to the superstructure of simply-supported steel bridges of spans up to 300ft. Where appropriate, the requirements of the specification may be adopted for larger spans or other types of steel bridges, but it is pointed out that care should be taken, in these circumstances, to make whatever amendments are necessary for fixity at the supports, continuity and other indeterminate or special conditions, such as, for instance, may apply to opening bridges.

Part 1 now refers to the use of steels to later British Standards and in it clauses are included on the preparation of edges and ends, conforming to developments in the technique of flame cutting. Sections are included on welding and on qualifications and testing of welders, and information on surface cleaning processes and metallisation by spraying is contained in a special section on protection against atmospheric corrosion.

ENGINEERS' COLD CHISELS

No. 3066 : 1959. Price 5s. This specification largely aims to minimise the risk of mishap to users of cold chisels by specifying well-defined hardness requirements that must be met at the time of manufacture. It also requires each tool to be marked to show the type of steel from which it has been made, thus reducing the possibility of the user's applying the wrong heat treatment.

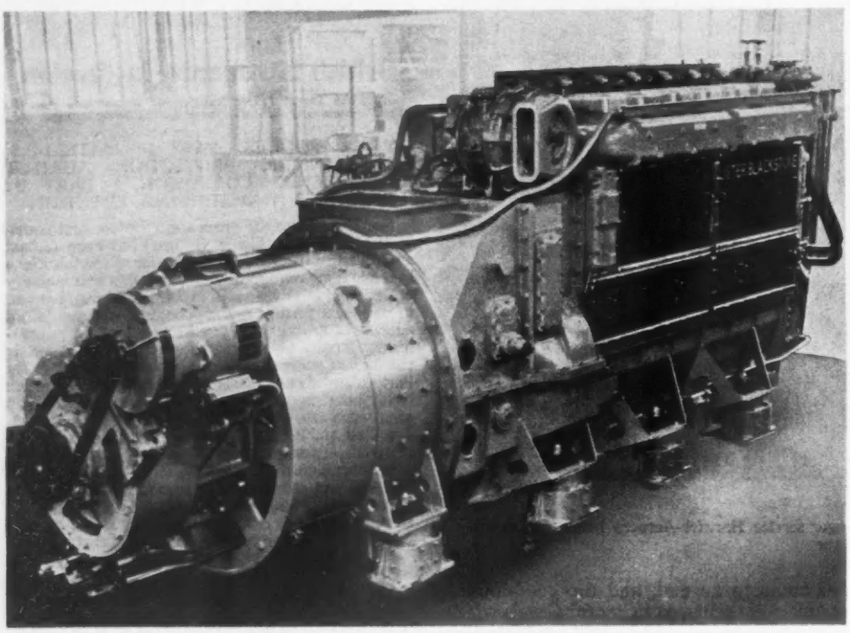
It deals with the nominal sizes, dimensions, quality, finish and testing of flat, crosscut, round nose and diamond point chisels in oil- and water-hardening carbon steels and in alloy steel.

PERFORMANCE OF DESK-TYPE ELECTRIC FANS

No. 380 : 1958. Price 6s. The desk-type fan for which the performance is laid down in this publication is the small high-speed, fixed or portable, propeller-type machine such as is normally used for circulating air in a room. Among the type tests (i.e. those to be made on a representative fan of each particular size and type) are those for air delivery, temperature rise—for which methods of measurement are specified—and service value. Routine tests (to be made on each fan) are those for high-voltage (application of 1000V under specified conditions), insulation resistance and earthing continuity.

Prototype Diesel-Electric Locomotive

A NEW 1100 h.p. diesel-electric locomotive with the C_o–C_o wheel arrangement has been developed by the British Thomson-Houston Company, Ltd., and Lister Blackstone Rail Traction, Ltd., for mixed traffic service on overseas railways. The design, called the "Explorer," is intended for systems where freight forms a large proportion of the total traffic and tends to be hauled in heavy trains at medium speeds. Since such lines are often of less than standard gauge and restricted to light axle loads, the prototype has been built to metre gauge, with an axle loading of 12 tons. The conception is essentially that of a locomotive adaptable to a wide range of requirements, with the result that certain details are variable. Height and width can be reduced from the figures shown on the accompanying diagram if this is essential, and the axle load can be increased to 14 tons if required.



Engine-generator set with belt-driven exciter. The main and auxiliary generators are driven from the two crankshafts through speed-increasing gears

Total weight of the locomotive is 72 tons minimum. Maximum service speed is 55 m.p.h., and maximum tractive effort 42,000 lb. The continuously rated tractive effort of 24,000 lb is exerted at approximately 12 m.p.h. A single step of traction motor field weakening assists the maintenance of the effort in the upper part of the speed range, and near maximum speed the figure is still approximately 5000 lb.

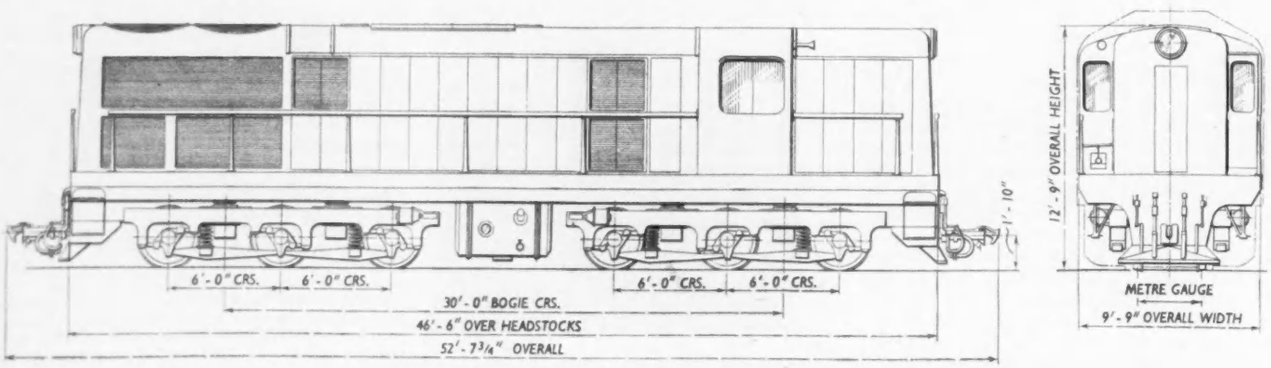
The Blackstone ERS.12–T four-stroke, exhaust turbo-charged diesel engine has two vertical banks of six cylinders driving parallel crankshafts which are geared to the main generator. A common shaft carries the auxiliary armature and a pulley on its end drives the exciter by vee-belts as illustrated. At an engine speed of 800 r.p.m., corresponding to the continuous rating of 1100 h.p., the generator is driven at 1125 r.p.m. This increase in speed has allowed the use of a light generator, and the arrangement also makes it possible to supply the power unit with a different ratio to meet particular operating conditions. Blackstone patented nodal damper couplings are interposed between the engine crankshafts and the generator driving gears. Either bank of cylinders can be uncoupled from the drive in emergency, enabling the locomotive to proceed on the other bank. A more detailed account was given on page 356, September 6, 1957.

The electrical transmission scheme follows the general lines of other B.T.H. locomotive installations, notably in the use of a separate exciter for the main generator instead of excitation being taken from the auxiliary machine. It is considered that this arrangement has advantages in reducing the currents to be handled by the automatic load regulator and in a slower response to changes in excitation, which reduces the liability to flashover. The six traction motors are connected permanently in parallel. Field weakening is initiated by the load regulator and full field is restored when necessary by a current limit relay. A pneumatic system provides stepless control of engine speed from idling (350 r.p.m.) to maximum. Initial movement of the power handle cuts out a fixed resistance in the exciter field circuit, after which excitation control is effected by the oil servo-operated load regulator.

A distinctive feature of the present scheme is the provision of dynamic braking. This is brought into action by a power/brake changeover switch which connects the motor fields in series to the main generator and closes each motor armature circuit through a fixed resistor. Braking effort is regulated by a control handle which actuates a rheostat in the exciter field circuit and so varies the output from the main generator (running at idling speed) to the motor fields. The resistors are ventilated by axial-flow fans driven by motors connected across sections of the resistance so that they operate during dynamic braking at a speed proportional to the braking current, and, hence, to the power to be dissipated. Slight dishing of the aluminium chromium stainless steel strip enables maximum cooling to be obtained from the flow of air. A centre-zero ammeter in the cab shows motoring current on one sector of its scale and braking current on the other. Braking services in the "Explorer" locomotive cover all normal combinations of requirements, comprising also a Westinghouse air brake for the locomotive and train, and Westinghouse exhausters for train vacuum brakes.

Mechanical parts of the locomotive have been built by the Clayton Equipment Company, Ltd. As the drawing shows, it has a single cab (with duplicate driving positions for each direction of running) located towards one end of a narrow hood enclosing the equipment. The traction motors are axle hung with plain sleeve bearings. There are two fixed bolsters in each bogie, with rubber pads supporting Alsthom rubber cone pivots on which the body is carried in conjunction with side bearers provided with coil springs and manganese pads. Each inner pivot assembly has lateral movement in its bolster to allow negotiation of tight curves, minimum radius being 300ft. The Alsthom system is also used for carrying the "Skefko" roller bearing axleboxes, which are supported from the bogie frame by upper and lower horizontal radius rods on "Silentbloc" bushes. Both these features have been proved in high-speed main-line service on the Continent, and at a demonstration at Rugby last week the smooth transition of the locomotive into the curvature of the test track showed them to be equally effective in conditions likely to be met on permanent way overseas. The freedom of vibration from the engine when idling and in motion was equally noticeable.

The "Explorer" locomotive is being despatched to Africa, where, with the co-operation of the East African Railways and Harbours, it is to run trials near Nairobi on one of the most steeply graded branch lines of that administration.



Dimensions of the "Explorer" locomotive for metre gauge

Naval Air Department at the Royal Aircraft Establishment, Bedford

BY OUR NAVAL CORRESPONDENT

AS part of the expansion of the Royal Aircraft Establishment, Farnborough, in the immediate post-war years, a new establishment was set up, near Bedford. At the same time it was decided that the two departments—the Naval Aircraft Department and the Carrier Equipment Department—concerned with naval aircraft problems, particularly with take-off and landing, should take advantage of the new site to install catapults and arresting gears and other essential new equipment for operating the coming generations of carrier borne aircraft. Over the years the installation of new equipment and the transfer of staff has steadily progressed, and the move was finally completed in September, 1957. In the transfer from Farnborough the two Naval Departments were reorganised and welded into a single unit known as the Naval Air Department.

The Catapult Site.—At the catapult site are two steam-powered, slotted-tube catapults. The installation of the first was completed in May, 1953—the tubes and track being those of the first steam catapult originally installed in H.M.S. "Perseus" (the aircraft maintenance carrier). This 200ft stroke unit is set in a deck mounted some 5ft above ground level so that aircraft can be launched into space as over the bows of a carrier flight deck. Steam is generated at up to 400 lb per square inch gauge in a Foster-Wheeler boiler and used to charge an accumulator which, in turn, is used to power the catapult. As installed in H.M.S. "Perseus," simple dry accumulators of 2000 cubic feet capacity were fitted. However, trials with a wet accumulator of less than half this capacity have shown that the same amount of energy can be stored and discharged more efficiently. The maximum energy level is of the order of 20×10^6ft-lb. A second catapult was recently installed at ground level involving the latest design of track ; also a new combined boiler and wet accumulator with a pressure capacity of 1000 lb per square inch. The track of this catapult is sited at ground level and the design includes means for launching a dead load—when means must be provided for catching and stopping same—or it can be used equally well for launching aircraft. In broad principle, the first, or "raised" catapult, is used for proofing aircraft and for investigating aircraft launching techniques. The second, or "flush," catapult is to be used for developing the catapult as a prime mover. The catching and recovery of aircraft launching bridles, without interference or prejudice to the launching cycle, is proving a frustrating and tantalising problem and a simple rocket catapult has been made up to throw the bridle only, at representative launching speeds, so that investigations may proceed independently of the overworked steam catapult.

Catapult Aircraft Loading Equipment.—This equipment (C.A.L.E.), although located separately in order to facilitate detailed investigation, is complementary to the catapult. A pilot cannot, with certainty, taxi his aircraft into the exact position required for catapulting, especially so with the carrier in heavy seas. The pilot taxies his aircraft so that the main wheels come up against roller-faced chocks, and in this position so long as the axis of the aircraft is within 2ft of the axis of the catapult, then the treads of the main wheels come to rest on sets of rollers flush with the deck. These rollers, their axes in a fore-and-aft direction, are driven by a hydraulic motor and by a process of preselection of the rollers to be driven, the aircraft (up to 40,000 lb weight) can be centred over the catapults within very close limits—power being available to do this even with the carrier rolling up to 4 deg. With the aircraft in position on the catapult and ready for launching with the engines at full power, a large area immediately aft of the aircraft would be untenable for either waiting aircraft or deck personnel, were it not for the presence of a blast deflector. The latter is, in principle, a large flat plate (the larger the better), set so as to deflect the engine efflux both upwards and outboard. However, this plate must be capable of being collapsed so that it will lie flush on the deck so that the succeeding aircraft can taxi over it to the catapulting position. It must be capable of being raised and lowered quickly, not to mention its ability to withstand the blast from, say, the two 10,000 lb thrust engines of the "Sea Vixen" or "Scimitar." That part of the deck between the aircraft, in the launching position, and the blast deflector, can acquire a considerable temperature from the aircraft engine efflux and, therefore, a system of deck cooling is required otherwise the temperature is a potential source of danger to the tyres of succeeding aircraft. The aircraft hold-back unit and pretensioning gear is unavoidably located in this area of inferno. Thus, the C.A.L.E. base is used to sort out and develop as good a harmony as possible between the several arduous requirements in this restricted area.

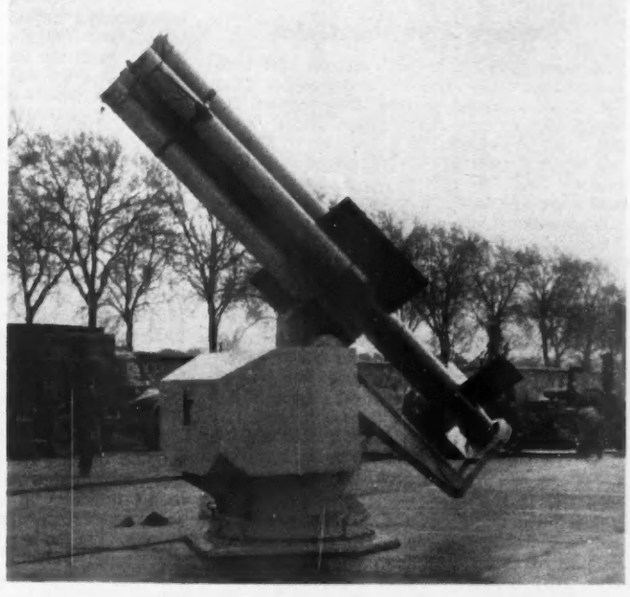
Safety Barrier and Arresting Gear Proving Base.—As the name implies, the S.B.A.G. base is used in the full-scale development of arresting gears, but instead of using aircraft the latter is replaced for test purposes by a wheeled dead weight running on rails, and is brought up to the required speed—representative of aircraft landing speeds—by a cordite-powered, slotted-tube catapult. This catapult has a maximum energy capacity of 40×10^6ft-lb, corresponding to 40,000 lb at 150 knots, when a charge of 300 lb of cordite is required. To date this maximum rating has not been used. When safety barriers are under test this same catapult can be used for launching into the nets, aircraft or similar test vehicles. At the forward end of the catapult and to either side of the catapult track, there are substantial steel grillages mounted on heavy foundations, to which can be fixed deck edge sheaves, energy absorber units, barrier masts, &c. There is a large straw-faced earth butt so located as to stop errant aircraft which may break through a barrier net. The dead weight trolley track terminates at the middle of the butt and here is located 40 tons of coke which can, and has, coped with a trolley that has broken an arresting gear centre span. If failure of a barrier net or centre span occurs it usually does so as a result of impact phenomena on engagement and before the speed of the vehicle is reduced significantly. Hence, the safety butt must be designed for all eventualities.

The Arrested Landing Deck.—This facility is in effect a representative section of the landing area of a carrier flight deck complete with the compartment immediately below the flight deck which accommodates the arresting gear energy absorbing units. This vault is located in a 2000 yards N.E.–S.W. runway, 650 yards from the N.E. end. It is designed to accommodate three units and is covered with steel decking finishing flush with the surrounding concrete runway surface. The vault is so designed that any one of the three arresting gears can be removed, installed or worked on, without having to disturb the decking. This is achieved by the main access to the vault being through a trunk, entry to which is located to one side of the runway. Each arrester gear is provided with two centre spans, the deck edge pulley spacing being adjustable between 130ft and 80ft in order to represent the different layouts on different carriers. The gears are used mainly for proofing aircraft on which clearances are given for arresting aircraft before proceeding with trials on a carrier at sea. In the case of heavy aircraft, which, for normal operation require more than 70 per cent of the capacity of the gear, the gear has to be specially rigged in order to apply to the aircraft the necessary proof loading, usually 50 per cent in excess of the normal maximum design loading. Normally, the gear is double reeved, i.e. four ends of the main reeve are connected to the four ends of the two centre spans. For the special rig, the four ends of the main reeve are attached, in pairs, to the ends of a single heavy centre span. In this way, the effective reeving ratio of the gear is reduced from 16 : 1 to 8 : 1, the run-out of the aircraft is halved, but effective proofing loads can be applied without overstressing the gear.

Ship-to-Air Weapon

A PHOTOGRAPH is now available of the Armstrong-Whitworth "Seaslug" ship-to-air guided weapon. It is seen (below) on a single launcher, which is recognisably similar to the trial launcher displayed at Farnborough : it is clear that no supplies to the vehicle are connected up. One striking characteristic visible is the way in which the weapon has been optimised for the minimum stowage and handling volume, with short wings and finless boosts : notice also that the boosts now extend virtually the full length of the nose. The flat caps seen appear to be secured by flagged safety pins : the explanation for this may be that frangible cases have been adopted, as on "Nike" installations, to reduce the risk of damage to the ship's consorts. The use of aft controls is not because of lack of experience with other geometrics, since Sir W. G. Armstrong-Whitworth Aircraft, Ltd., have built and flown canard cruciforms : it is probably justified, although the combustion chamber must be near the wings, by the fact that the guidance of a beam rider can be located near the tail, and thus all controls, generators, and other items requiring functional testing can be aft and isolated from the explosive-laden centre and nose section.

An accuracy of a very high order is claimed for this weapon : it will be recalled that a warship is a difficult target for aircraft, and can expect to engage them at relatively close range.



The "Seaslug" ship-to-air guided weapon as shown recently to the military leaders of NATO Powers at Supreme Headquarters Allied Powers, Europe. In the background can be seen an operational launcher for a "Thunderbird"

SHORTER REPORTS

Association of Consulting Engineers

AN optimistic note was sounded by Mr. Vaughan-Morgan, the Minister of State, Board of Trade, in the speech he made at the Association of Consulting Engineers' annual dinner on February 16. He pointed out that in spite of all the turbulence and turmoil in the Middle East, that area continued to grow in importance as a market for this country. He congratulated the Association on the growth of its overseas work—work for which British consultants were responsible currently amounted to £550 million, he said. The corresponding total last year had been £505 million and that step forward had been achieved in a year of recession. Mr. Vaughan-Morgan also referred to lack of capital for development, and asserted that it was important that British firms seeking work overseas should be thoroughly familiar with and understand the various sources, both national and international, from which development capital could be obtained.

The chairman of the Association of Consulting Engineers, Mr. J. T. Calvert, expressed regret that the Ministry of Supply had ordered radio telescopes from Holland. He went on to discuss advertising, and contractor's design services. Independent design, which promoted competition at the tender stage, had advantages, he asserted, and in his view " all-in " bids were not advantageous. Mr. Calvert then went on to explain that the Association planned to broaden its basic requirements for membership. Corporate membership of one of the three major engineering Institutions was at present a qualifying requirement, but it was intended to recognise for this purpose corporate membership of the Institution of Structural Engineers, the Institution of Chemical Engineers, and the Institution of Mining and Metallurgy. He hoped that the formalities would be concluded this year. Mr. Calvert also stated that the civil engineering scholarship trust (see THE ENGINEER, January 17, 1958, page 82) had financed ten students this year, and there would probably be fifteen more students next year.

Strategic Freighter Order

A NUMBER of " Britannic " aircraft have been ordered from Short Brothers and Harland, Ltd., for employment as strategic freighters by the Royal Air Force : the machine should fly in 1961 and it is hoped that production aircraft will become available towards the end of 1961 or early 1962. This delivery is regarded as early and attributed to the fact that the new aircraft will have many parts in common with the Bristol " Britannia." The only engines available in this country being the Rolls-Royce " Tyne," the resulting design is intermediate in size between a Lockheed C-130 " Hercules " and a Douglas C-133, and its general arrangement closely follows those of the existing transports : thus it is not similar in appearance to the " Tyne " powered " Britannia " derivative being built by Canadair, Ltd., for the Royal Canadian Air Force. The freight hold will be 80ft long, 12ft high and 12ft wide at floor level, and be capable of carrying an Albion 10-ton crane or the large radar trailers needed for guided weapons installations.

The " Britannic," or S.C.5, has the same wing, tailplane and fuel, flying controls and electrics systems as the " Britannia " : although the undercarriage is installed in the fuselage, it is almost identical with that of the airliner. The maximum payload will be 75,000 lb, with an all-up weight of 195,000 lb, corresponding to a 1400-mile still air range at 360 m.p.h. With a full fuel load, 30,000 lb can be carried 5500 miles. The aircraft is considered to have a potential civilian market, and a passenger version would carry 197 passengers 2600 miles at 350 m.p.h., or ninety passengers 5500 miles.

It is interesting, in view of the abandonment of the General Dynamics " Britannia " successor, to note that there is expected to be a developed version of the " Britannic " with a thinner, high-aspect ratio wing, with an increased all-up weight of 220,000 lb, and a payload of 100,000 lb in a longer fuselage.

National Water Resources

Two reports which deal with fundamental matters in the future development of the water industry in this country were published yesterday by the Ministry of Housing and Local Government. Both of these reports have been prepared by sub-committees of the Central Advisory Water Committee, and they deal respectively with the growing demand for water, and with information about water resources. Both reports are available from H.M. Stationery Office. The two sub-committees were appointed in 1955. The main conclusions which they have now reached will be of very general interest, and are summarised hereunder.

Available supplies of water will exceed the net demand in all areas of England and Wales in 1965. Up to this date, development schemes prepared by water suppliers should enable them amply to meet likely demands on them. Provided that the proper means of conservation and distribution are developed, the country's rainfall is sufficient to ensure an adequate supply of water to meet the growing needs of the more distant future.

More information is needed, however, on water consumption and resources, particularly private supplies, and it is desirable that hydrological surveys to obtain comprehensive information should be started. The work being done on hydrological research should also be reviewed to determine how such work should be co-ordinated and what further work needs to be done. The arrangements for collecting information about rainfall, snowfall, river flows and ground water broadly meet the known need, but they could usefully be extended in some respects and more information should be published, on a common basis of river basin areas.

New works already under construction or proposed by public water undertakers provide for a further yield of about 1000 m.g.d., and over 800 m.g.d. of this total (about 40 per cent of the amount of water distributed by the undertakers in 1955) is expected to be available by 1965. This would " amply cover " the average expected rise in demand on public water undertakers—put by them at 23 per cent—during the period 1955–65. The value of these works was given as £300 million over the ten years, but the sub-committee thinks investment may be needed at a rate somewhat higher than £35,000,000 a year (at present-day costs) as sources become more difficult and costly to develop.

Because many industrialists take their water supplies directly from such private sources as wells, river intakes and canals, the sub-committee found difficulty in getting exact information about water requirements to be met from private sources. On the basis of returns from the major water-using industries, plus the nationalised industries, the sub-committee assumed a general increase in industrial demand for water in all areas of 25 per cent in the period 1955–65. It concluded that " in the shorter term the likely increase in (private) demand can be met in each area taken as a whole, although local difficulties may arise."

Emphasising that " a satisfactory situation in the future must rest on the readiness of all concerned to regard water as a valuable commodity and to provide money and materials accordingly," the report offers the opinion that there need be no shortage of water in any part of England and Wales after 1965 if four conditions are satisfied, namely (1) development schemes are prepared well in advance of demand ; (2) the necessary statutory powers and other authorisations are granted ; (3) capital investment is permitted on the requisite scale ; (4) the location of industries which require large quantities of water is regulated with the water supply situation in mind.

The sub-committee does not consider it wise to attempt numerical estimates of water supply and demand after 1965, but very approximate computations of the total flow of water from all areas in England and Wales indicate the presence of large reserves. The report shows wide differences between areas in the percentage of this total flow expected to be used in 1965—in some places a development of over 35 per cent is visualised, but in England and Wales as a whole the proportion is only 11 per cent. The sub-committee therefore believes that further development of water resources is possible in most areas and that in a few of them there is scope for extensive development. They point out that assistance can be given from one area to another.

The estimates in the report do not allow for the development of agricultural irrigation—" still in its infancy "—but it is pointed out that the potential water demand for this purpose is very great. The sub-committee is undertaking further study of the problem, including the possibility of some form of control over abstraction of water from rivers and streams, and hopes to make recommendations in its next report.

The sub-committee on information about water resources comments on the slow progress made so far on the provision of primary river gauging stations and urges that vigorous action be taken to complete the approved programme within the next two to three years.

Ships Launched in 1958

LLOYD'S REGISTER OF SHIPPING has issued its *Annual Summary of Merchant Ships Launched in the World during* 1958, which records that in Great Britain and Northern Ireland 282 ships of 1,401,980 tons were launched, of which 39 were steamships of 498,967 tons and 243 were motorships of 903,013 tons. The total represents 15·1 per cent of world output and includes 48 oil tankers of 577,385 tons, or 41·2 per cent of the total returns. Of the tonnage launched, 53 ships of 337,868 tons, or 24·1 per cent, are for registration abroad. Abroad, 222 steamships of 3,438,338 tons and 1432 motorships of 4,429,665 tons, making a total of 1654 ships of 7,868,003 tons, were launched, of which Japan's share was 2,066,669 tons and Germany's share was 1,429,261 tons. Oil tankers numbering 381 ships of 4,197,894 tons, represent 53·4 per cent of the total. Of the tonnage launched, 4,146,122 tons, or 52·7 per cent, are for export, and includes 1,256,593 tons by Japan, 860,262 tons by Germany, and 469,355 tons by Sweden. Throughout the world launchings totalled 9,269,983 tons, of which Japan accounted for 22·3 per cent, and Germany 15·4 per cent, and Great Britain and Northern Ireland 15·1 per cent. Oil tankers launched amounted to 4,775,279 tons, or 52 per cent of the total, while of the total 58 per cent are motorships. The ships being built under survey of Lloyd's Register represented 4,328,151 tons, or 46·7 per cent.

Main Line Diesel Locomotives*

By T. SCHUR, B.Sc. (Eng.), M.I.Loco.E., A.M.I.Mech.E., A.M.I.E.E.

THE evolution of the diesel locomotive, like most technical developments, has been accompanied by certain disappointments and even serious failures, but these have contributed much to the design as we know it to-day. These failures are ascribed by many—not only by those brought up on steam traction—to the many small components which go to make up this newcomer. Despite their complication, however, diesel locomotives can and do show outstanding successes in performance, reliability and, not least of all, in economy. Such successes are now an accepted fact and have been gained by hard practical experience and thorough development of straightforward designs.

Whilst simultaneous with this line of development some revolutionary designs are appearing from time to time to catch the limelight of publicity and to point the way to higher specific performances, real progress has been due to the more prosaic evolutionary process in which increased specific performance is carefully weighed against requirements of service reliability and economy. To obtain the best performance for a given weight requires a careful and scientific study of each component, not only of the structural part of the locomotive, but also of engine framing and similar parts. To ensure service reliability and economy, the designer must base his decisions on long service experience, and choose a straightforward design with a few large and robust parts in preference to a multiplicity of smaller ones.

One of the most interesting developments to-day is the introduction to British Railways of many greatly differing types of diesel locomotives. The service performance of these different designs will indicate what basic considerations the designer of diesel locomotives should in future follow.

The author, who is on the manufacturing and design side, can only point to some of the earlier experiences and theoretical considerations that have gone into the locomotive designs with which he is currently associated.

It is now standard practice on main line locomotives to house the power equipment on a chassis and inside a body carried on driven trucks or bogies. In the past it was sufficient to provide an underframe to carry the weight and a body to keep out dust and rain, but this is not now the case. With very few exceptions, the quest to-day is still for more power on a given wheel arrangement than can conveniently be provided by conventional means.

To achieve this, the first parts to be scrutinised for weight saving should be the body and underframe of the locomotive and it is the author's experience that these parts can be constructed to the same mechanical requirements with vastly differing weights. Not enough has yet been done really to design these mechanical parts and too often there is insufficient integration between chassis and body making for extra weight in these parts. The result of such heavy building will inevitably be the quest for ultra-light power units with a consequential sacrifice of ruggedness where it is most needed.

There are three basic designs of underframe and body construction. First of all, there is the underframe, which takes all the buffing and bending loads with the body fitted loosely as a shelter for the power equipment. Secondly, there is the trussed girder type of construction, whereby a bridge girder is built up on the sides of the underframe to help carry the weight of the power equipment. Thirdly, there is the stressed skin design, where underframe and body are built as an integral whole with every part of the body, including the cantrail and skin, sharing in the load carrying.

It is quite clear that the separate underframe type is by far the heaviest, but weight calculations sometimes show the girder type to be the lightest. This is particularly so when relatively light buffing loads are assumed and the structure is designed primarily to carry the weight of the power equipment. In actual fact, the stressed skin type shows the greatest advantages, because it is not only stronger than the girder type, weight for weight, as far as buffing loads are concerned, but it is also less wasteful in space requirements so that the locomotive can be shorter. The heavy members which connect the girder trusses with the main longitudes, as well as the truss members themselves, are absent in the stressed skin design and this makes room for the accommodation of parts of the equipment. The stressed skin type cannot easily be calculated and is generally approached more on an empirical basis with new designs following strain gauge tests made on previous units.

[The paper then deals in some detail with the design of the mechanical parts of a diesel locomotive, diesel engines used in traction and their construction, transmission and control. It concludes with the following remarks.]

A diesel locomotive can become a very complicated machine. The multi-cylinder engine alone tends to the complex and, due to its flat torque characteristic, it requires the addition of an elaborate transmission. The range of this transmission is usually restricted so that control gear is required to repeat the range over various stretches of the tractive effort characteristic. At this point it is tempting to add further control gear to limit the speed of changeover, to depress power during transition and to limit excessive tractive efforts. It is only too easy to imagine all possible contingencies in engines, transmissions, auxiliaries and control gear and to add even more relays for equipment protection and for fault indication of doubtful value. Once protection against maloperation becomes an obsession the locomotive finishes up with two engines, two transmissions and the duplication of auxiliaries and controls on the dictum that if one fails the second is available. The diesel locomotive thus reaches the acme of complexity and those who cherish the simple steam locomotive are quite right in their condemnation of this new monstrosity.

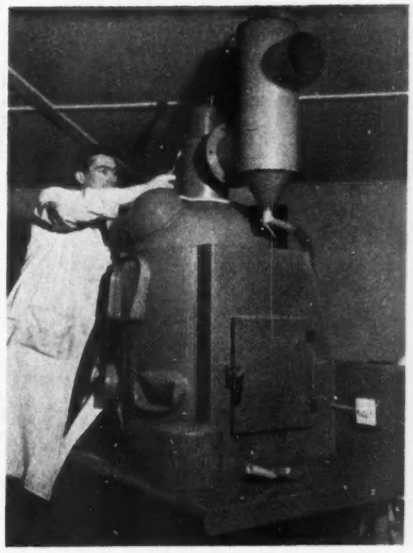
The diesel locomotive need not be complicated, even though demands for high performance and maximum utilisation, for service economies, as well as for easy handling, must be met. All these requirements can be achieved in a straightforward design, but only by the most thorough integration of every part of the equipment with due appreciation of the importance of each. Mechanical parts must be designed around the power equipment, which must be laid out in a clear and logical manner. One engine should be sufficient for any locomotive and this should comprise a small number of cylinders and working parts. One traction motor per axle or one torque converter per bogie is a good arrangement and preferable to the use of extra gear to interconnect axles. Auxiliaries and control must be robust and must never assume an importance greater than the equipment they serve. Finally, the provision of extra equipment and gadgets must be avoided and ways must be found to get the requisite performance through the correct shaping of inherent machine characteristics and by the relegation of certain functions to robust and traction-proved governors.

The diesel locomotive is first and foremost a traffic machine and can give an admirable account of itself, both in reliability and economy. It can be made pretty foolproof and will stand a lot of mishandling by the crew. There is just one thing it will not stand and that is a lot of gadgetry.

* Abstracted from a paper "Some Design Considerations of Main Line Diesel Locomotives," presented to the Institution of Locomotive Engineers on February 19, 1959.

Vapour Blasting Equipment

WE illustrate a vapour blasting equipment, fabricated from "Vybak" industrial rigid p.v.c. sheet made by Bakelite, Ltd., which is now being marketed under the trade name "Hydrotron" by Metachemical Processes, Ltd., of Crawley, Sussex. It is built almost entirely from plastics materials and comprises basically a blasting cabinet and supporting structure, beneath which is located a large polyethylene container for holding the abrasive slurry. Compressed air is used to convey the slurry from the container to the blasting gun housed in the cabinet. The unit includes a rigid p.v.c. extractor with a nylon impeller; built-in rubber sleeves to protect the operator's hands, and an automatic washing device for the observation window.

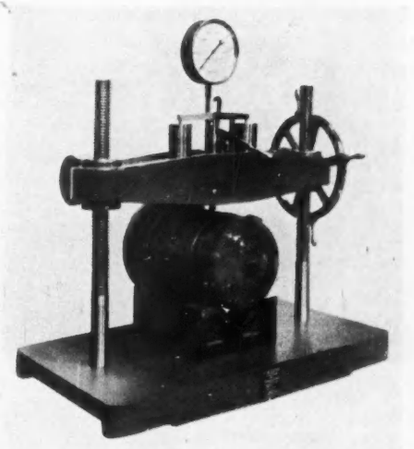


Vapour blasting unit fabricated from p.v.c. sheet

Amongst the advantages claimed for this form of equipment is that the abrasive within the slurry cannot be contaminated by the material used in its construction, and abrasives, or grades of slurry, can be quickly altered merely by changing over to another polyethylene container. The slurry feed system and working cabinet can be quickly and easily washed down when changing from one metal or slurry to another.

Adjustable Head Brinell Hardness Tester

A BRINELL hardness testing machine, specially intended for testing large components and now being made by Edward G. Herbert, Ltd., Levenshulme, Manchester, 19, is illustrated below. It has a 44in by 24in table with a clearance of 30in between the screwed columns supporting a crosshead carrying the testing equipment



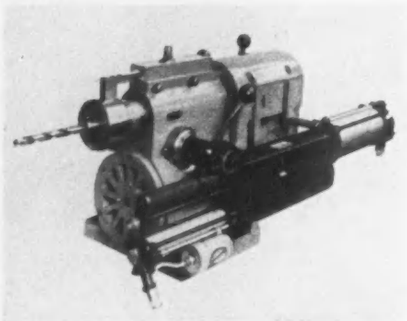
Brinell hardness tester for large components

Through the screw adjustment the crosshead can be set to give a maximum distance of 24in between the table surface and a 10mm diameter steel ball.

The standard Brinell head equipment on the crosshead includes an 8in diameter 0 to 3000 kg pressure gauge, checkweights, a hand-operated pump and a 10mm diameter ball support. Height adjustments to the crosshead are made by a single handwheel on one side which operates the coupled nuts on the column screws.

Unit Drilling Head

A UNIT head with a capacity for drills up to 1¼in diameter is now being made in a number of models to suit different applications by Grimston Electric Tools, Ltd., Progress Way, Purley Way, Croydon, Surrey. These self-contained units, one of which is illustrated below, are driven by a 0·9 h.p. motor mounted in the base. The motor



Unit head for 1¼in diameter drills and having four spindle speeds and four feed rates

drives the spindle through a four- or eight-speed selector gearbox. A number of gearboxes covering grouped speed ranges are available for fitting on the units and the overall spindle speed range provided is from 90 to 4000 r.p.m.

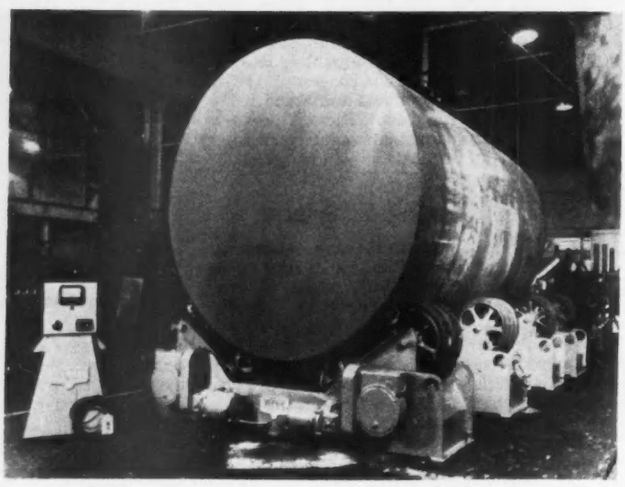
The quill mounted spindle has an effective drilling stroke of 4½in, and through the power feed mechanism four feed rates from 0·0035in to 0·008in per revolution are available. A ring fitted on the nose end of the quill carries a graduated stop bar ; a trip can be positioned on this bar to disengage the feed and control the depth of drill feed. If required a hydraulic-pneumatic control unit such as that shown in the illustration can be fitted. This control is adjustable and gives automatic rapid drill approach to the work, changing to the required feed rate, followed by rapid withdrawal at the end of the preset feed stroke of the spindle. We are informed that multi-spindle drilling attachments are available for use with these new units.

Self-Aligning Rotator for Welding Large Vessels

A 30-TON capacity self-aligning rotator made for handling work during automatic welding by Yates Plant, Ltd., Whidborne Street, London, W.C.1, is shown in operation in the photograph we reproduce. In this particular case the equipment includes three additional sets of idlers, which enable vessels up to 100ft long and 16ft diameter to be handled. The rotator is operated from a control box mounted on a portable pedestal, and through the Ward-Leonard drive gives a stepless range of welding speeds from 4in to 40in per minute.

The self-aligning rollers automatically accommodate themselves to different diameter vessels to support and rotate them about a common centre line. The idler assembly incorporates an anti-creep control means, which is adjusted by a handwheel to correct any tendency the work has to creep in either direction during rotation.

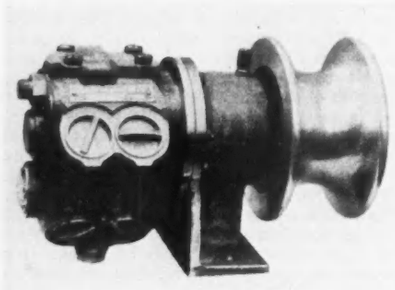
A geared motor at each end of the drive unit of the equipment transmits the drive to a drum through a final reduction gearbox. These drums provide a friction drive to the heavy-duty rubber-tyred rotator rollers, and this form of friction drive prevents possible damage to the main gearing and motors when loading heavy vessels on to the machine. It also provides a degree of protection against mechanical damage should the machine be overloaded.



30-ton self-aligning rotator incorporating anti-creep mechanism

Portable Capstan Winch

WE illustrate a new portable pneumatic capstan winch capable of lifting 300 lb, which has been designed and developed by Globe Pneumatic Engineering Company, Ltd., of Romford, Essex, for use in the building, transport, and other industries where light lifting and hauling duties have to be carried out. The winch has a four-cylinder vee motor, developing a high starting torque, and with a working pressure of 80 lb per square inch at 40 cubic feet of free air per



Air-driven capstan winch for lifting loads of up to 300 lb

minute the unit has a maximum lifting speed of 80ft per minute.

Complete with a machined aluminium capstan head the winch weighs only 35 lb. It cannot be damaged by overloading or stalling and is stated to be unaffected by corrosive or damp atmospheres. Either foot or hand valve controls can be fitted to the winch and the direction of rotation can be instantly changed by reversing the air flow.

40 MeV Linear Accelerator for Deutsches Elektronen-Synchrotron, Hamburg

A 40 MEV electron linear accelerator for Deutsches Elektronen-Synchrotron (D.E.S.Y.) Research Group, Hamburg, is being designed and built by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. This interesting export order is worth about £250,000.

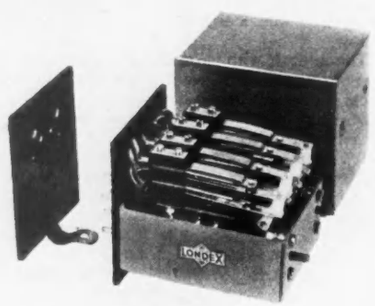
The accelerator will be used to inject a beam of 40 MeV electrons into a large electron synchrotron, which will then further accelerate the electrons to an energy of 6000 MeV. To make this further acceleration possible, very rigorous restrictions are necessary on the output of the linear accelerator used for injection. Very little variation is permissible on the specified 40 MeV energy, and the electron beam must be small in diameter, and must have very little divergence.

The linear accelerator, which is a travelling-wave equipment, will be energised by short wavelength radio-frequency power, and the electrons will be accelerated along a specially shaped waveguide. The output of the accelerator at 40 MeV is in the form of short pulses of current of 2 microseconds duration, repeating fifty times per second. Each pulse of current must supply 125mA within the strict limit of energy and beam geometry imposed by the acceptance requirements of the synchrotron.

The equipment has an overall length of approximately 35ft, and consists of five sections of accelerating waveguide, each 1½m long, together with an electron gun and prebuncher at the injector end. Each accelerator section will be fed by a Metropolitan-Vickers high-power klystron. A considerable amount of associated equipment, including the klystron power supply, together with controls and other services, is also included in the contract.

Plug-In Relay

A NEW version of the "Londex" type LF relay, made by Londex, Ltd., 207, Anerley Road, S.E.20, is now available in which a plug-in mounting facilitates maintenance or replacement. An eighteen-way plug and socket is used, allowing for a wide variety of contacts to be accommodated. The illustration shows the retaining clip fitted to the socket, which holds the relay firmly in



Plug-in relay with eighteen-way plug and socket, showing retaining clip on socket plate

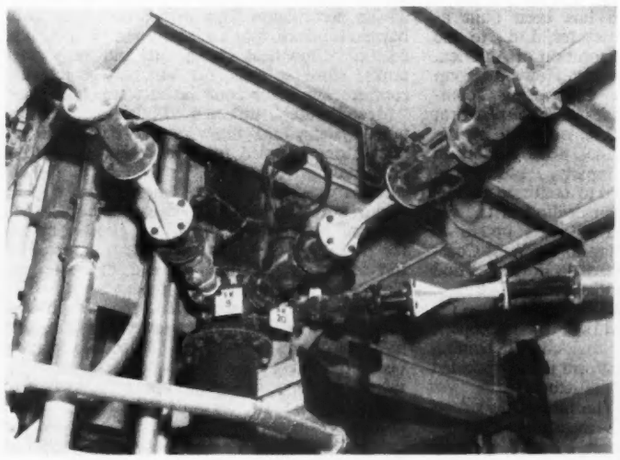
position. The maximum number of contacts provided is eight normally open or eight normally closed, or any combination ; alternatively, five changeover contacts can be fitted. The contact rating is 4A at 250V a.c. Operating voltage for the coil can be from 2V to 600V a.c. or up to 180V d.c. The power required is from 4VA to 12VA, depending on the number of contacts. Overall dimensions of the relay are 2¾in by 3½in by 4⅜in.

Soviet Atomic Power Stations

ACCORDING to press reports, the first stage of the second nuclear power station in the Soviet Union went into service last September. It is described as of 100MW capacity, while the complete station will have a capacity of 600MW. A third station is being built in the Urals. This is being equipped with a graphite-moderated reactor which will produce superheated steam. The steam is to be used directly in the turbine giving an overall efficiency of 37 per cent. The fourth station, in the Voronezh region, will develop 420MW, and will be equipped with two water-water reactors in which ordinary water under a pressure of 100 atmospheres will be used as moderator. A similar station is planned for the region of Leningrad. Work is also going on with regard to fast breeder reactors. A 50MW reactor of this kind will, it is stated, be erected on the Volga.

"Sonic" Pneumatic Conveying System

PARTICULARS have been released by Henry Simon, Ltd., Stockport, of a new system of pneumatic conveying which is claimed to be superior to present conventional methods, and is known as the "Sonic" conveying system. The firm points out that when materials are conveyed pneumatically between different parts of a plant it has hitherto been necessary to provide a separate compressor for each blowing line because, if a number of lines powered from a single compressor were used, it was found that the air tended to take the path which offered the least resistance, and those lines which were heavily loaded were by-passed and became blocked. In investigating this problem the firm decided that what was wanted was a valve which, when installed in a blowing line, would keep the resistance of the line constant irrespective of the load. In a system fitted with such valves any number of lines could be powered from one compressor without any interaction. The simple, reliable, economical and automatic "Sonic" valve was therefore developed.



"Sonic" valves in a pneumatic bulk handling system in a biscuit factory

The valve consists of a convergent-divergent nozzle so proportioned that the air passing through reaches the velocity of sound. With a "Sonic" valve interposed between a loaded line and the compressor, a pressure wave travelling towards the compressor as a result of a load change is halted at the valve throat, since the wave velocity of propagation is exactly equal to the opposing air velocity. In other words, the "Sonic" valve introduces a sound barrier between the compressor and the varying line resistance. This is the principle of the "Sonic" valve, but it was found that a simple orifice construction introduced a pressure loss which was completely unacceptable, and further research was devoted to developing a low loss nozzle. It was found that by careful selection of the profile and special attention to the surface finish during manufacture, it is possible to reduce pressure loss to negligible proportions.

The new system is stated to be inherently more stable and versatile than one in which each line is powered by its own compressor and where the air flow in the lines decreases with increased load, due to compressor characteristics, whereas the air flow through a "Sonic" valve remains constant. These valves are made of aluminium, and fitted with an adjustment by which the flow can be preset to any desired value. This value is then held by the valve regardless of load changes, and the provision of an adjustment enables valves to be set to suit flow changes, so that a range of valves to particular requirements is not needed.

The first of the new conveying systems is now in operation in a Liverpool biscuit factory, and part of it can be seen in our illustration. In the installation, all the blowing lines are powered from a central compressor and the whole plant can be controlled from a central control room.

Rescue and Salvage Tugs

ONE of the two high-powered, twin-engined single-screw rescue and salvage tugs, the order for which was placed by the Polish Salvage Company, of Gdynia, has been completed at the Albion Dockyard of Charles Hill and Sons, Ltd., Bristol. The form adopted for the two tugs was tank tested at Wageningen, Holland, and the first vessel, the "Jantar," can be seen in our illustration undergoing trials. Mainly of welded construction, the tug has been strengthened for navigation in ice and complies with Ministry of Transport regulations and has been built under the inspection of Lloyd's Register; the following are the main particulars :

Length overall, metres	65·50
Length between perpendiculars, metres ...	60·00
Breadth moulded, metres	11·89
Depth moulded, metres	5·79
Draught aft, metres	5·50
Trim bi-stern, metres	1·97
Freeboard amidships, metres	1·22
Displacement loaded, tons	1650

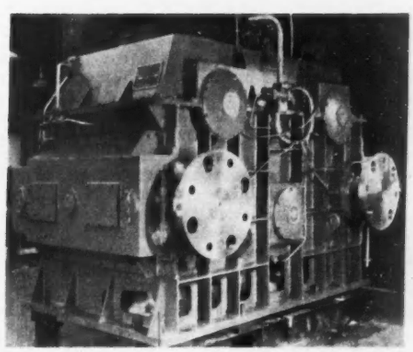
Polish rescue and salvage tug "Jantar" on trial

In a house on the bridge deck is a suite for the captain and cabins for deck officers, while in the house on the forecastle deck are located the officers' and crew's dining saloons and the galley. On the main deck within the long forecastle there is a hospital and cabins for the engineers and seamen and also a doctor, and on the lower deck forward the salvage personnel are accommodated. Altogether the ship carries a complement of twelve officers and twenty crew and twelve salvage experts including two divers, and the accommodation is equipped with Steel's mechanical ventilation and is heated by steam radiators. Well forward is a hold used as a general store and aft is a hold for salvage gear. The machinery is arranged in three spaces, largely dictated by damaged stability conditions, forward is the generator room then the main machinery room and aft the gearing compartment. A total of 272 tons of oil fuel is carried in transverse bunkers forward of the generator room, in the double bottom under the generator room and in tunnel wing tanks, and if required the wing water ballast tanks in the tunnel can take a further 53 tons while the upper wing tanks in the after peak have the capacity for an additional 26 tons.

Deck machinery, supplied by Clarke, Chapman and Co., Ltd., consists of an electric windlass, an electric capstan aft with under deck motor and a towing winch placed on the main deck at the break of the forecastle. The centre barrel of the winch has a capacity of 300 fathoms of 6in steel wire and the winch can maintain any pull between 5 and 34 tons, and also operates a 10-ton derrick mounted on the main mast. Other equipment includes under-water welding equipment, a Siebe Gorman decompression chamber for divers and a two-stage air-cooled air compressor. A Merryweather salvage and fire pump rated at 400 tons per hour when supplying the monitors and 480 tons per hour on salvage duty is installed and there are two Reavell compressors each able to deliver 176 cubic feet of free air per minute at 350 lb per square inch.

A Cochran vertical oil-fired boiler with a capacity of 1390 lb of steam per hour meets all the demands of the ship's services as well as those of the de-icing arrangements. Three 150kW Brush 220V d.c. generators, each driven by a National five-cylinder diesel engine, provide electrical power, while a 30kW generator in the main engine-room meets harbour duties and is driven by a McLaren diesel engine which also drives a compressor rated to deliver 9·2 cubic feet per minute of free air at 350 lb per square inch.

The main propulsion machinery consists of two National Mark B.4AUM7 exhaust gas pressure-charged and inter-cooled four-stroke diesel engines having seven cylinders of 17in bore by 21·5in stroke and each rated at 1575 b.h.p. at 333 r.p.m. The power from each engine is transmitted to a twin-input single output Hindmarch/M.W.D. oil operated reverse reduction gearbox through Vulcan-Sinclair scoop controlled hydraulic couplings. The Mark 2MWR size 10 reverse reduction gear, seen in our illustration, transmits the total input of 3150 b.h.p. at 333 r.p.m. to the propeller shaft at 120 r.p.m., the propeller having a diameter of 13·21ft by 14·875ft pitch.



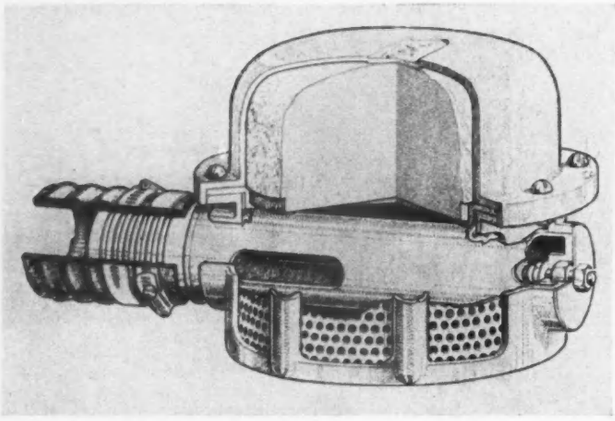
Hindmarch/MWD oil-operated reverse reduction gear

On trials, plotted by the Decca Navigator system, a free running speed of 15·44 knots was attained, while with one engine shut down the speed was 12·96 knots. Oil consumption indicated a radius of action of 9900 miles at full speed and in excess of 19,000 miles at an economical speed. The static bollard pull achieved was 25 tons and the turning circle had a tactical diameter of 375m, the full turn occupying three-and-a-half minutes, while the time taken to stop the ship from full ahead was one minute fifteen seconds, the distance covered being 335m. In the contract conditions the metacentric height is 0·98m, giving a stability range of 67 deg. with the forecastle open, and over 90 deg. with the forecastle closed.

Floating Suction Strainer for Pumping Systems

A NEW design of floating strainer for pumping installations has been developed by Megator Pumps and Compressors, Ltd., 43, Berkeley Square, London, W.1, and is at present being made in four sizes to suit 1½in, 2in, 3in and 4in suction hoses. This strainer is designed to float on the water and draw from a level just below the surface, so that under normal conditions sand and silt from the bottom or floating debris from the top of the water is not drawn into the suction line through or on to the mesh.

The general construction of the new unit, which is known as the "Dolphin" strainer, is shown in the accompanying drawing. Other than the stainless steel bolts and screws all parts are made of high-strength polystyrene mouldings, so that the strainer is unaffected by water containing corrosive or other harmful fluids. The



Floating suction strainer of high strength plastics material and designed to draw water from just below the surface

design is essentially simple and the unit can be quickly and easily dismantled for the replacement of any part without the use of special tools.

The cylindrical base has large open areas round its side walls and is lined with a closely fitting perforated member through which the water is strained. Deep flanges moulded on opposite sides of the base wall freely support a rotatable tubular member, which is coupled to the suction hose and is slotted to permit the intake of the water. This intake tube is held in the body between a flange formed on its hose coupling end and a stainless steel disc which is bolted on the opposite end and overlaps the end of the supporting flange in the base. Screwed to the top of the base is a float chamber which is filled with a moulded block of polystyrene "foam" to provide the required buoyancy. Should this top cover be perforated or damaged in any way the effectiveness of the "foam" remains and the buoyancy of the strainer is in no way impaired.

A particular point in the design of this strainer is the freedom of the intake tube to rotate in the body, so that, should the hose to which it is coupled be twisted, the tube simply turns in the body. The strainer thus always remains on an "even keel" with the intake section of the body below the level of the water. It will be noted that the slotted entry ports to the tube are situated near the hose end and at its other end the tube is closed; it does not matter, therefore, if the strainer is tilted a certain amount as the inlet to the tube will remain submerged. These points in design are stated to be particularly advantageous when a strainer is used in mines or excavations where a pump is working under "snore" conditions to keep the level of water as low as possible. The flat bottom of the strainer, combined with its light weight, also reduces any tendency to sink or be sucked down into sand or silt on which it may be resting under such conditions of operation.

The makers expect that this design of strainer is likely to overcome the tendency for air to be entrained into a pump due to vortex formation. Experience has indicated that it prevents the formation of vortices, first, by reason of the cylindrical arrangement of the entry holes, and, secondly, because any tendency to vortex formation is automatically countered by a slight sinking of the strainer, so that a vortex-free position of equilibrium is established.

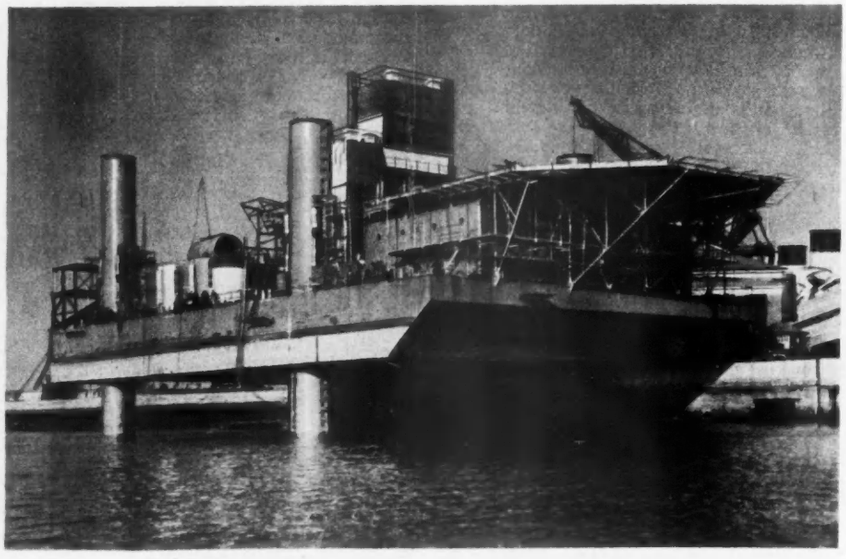
Mobile Oil Drilling Platform "Orient Explorer"

THERE recently sailed from Southampton, on its long tow of 9200 miles to the South China Sea, the mobile oil drilling platform, "Orient Explorer," which has been built at Southampton by Steel Structures, Ltd., to the designs of the DeLong Corporation of America, which is an associate of the John Howard Group of engineering companies. The platform will be operated by the Brunei Shell Petroleum Company, Ltd., and used to continue exploration drilling in the sea bed in areas up to 40 miles off the West Coast of British Borneo. Food supplies and light freight will be conveyed to the platform by helicopter, for which a landing platform is incorporated in the structure.

The hull of the structure measures 190ft in length by 106ft wide by 16ft deep, and is fitted with four retractable legs, each 235ft in length by 10ft in diameter and having two heavy slotted jacking bars welded lengthwise and diametrically opposite each other. Erections above the hull include a large deck house, to accommodate the personnel, over which is the helicopter landing platform, designed to withstand a wind force of 100 m.p.h., mud and chemical hoppers, and the drilling rig gantry. Approximately 3000 tons of steel have been incorporated in the structure, which has a total weight of 5400 tons. The general design of the platform provides for it to withstand waves 30ft in height when operating in water 100ft deep; however, under certain conditions, it is possible to work in water 125ft deep. Our illustration shows the platform approaching completion at Southampton with the legs spudded in and the platform raised. It will be noticed that, for reasons of stability during the long tow via the Suez Canal to the South China Sea, the legs have been only partially built, the remaining sections being stowed on deck ready for completion of the work on arrival.

Completely self-contained and air-conditioned accommodation is provided for an operational crew numbering fifty-six, and for drilling purposes there is an Ideal 80B drilling rig, having a maximum operational depth of 12,000ft, together with two E500 Ideal slush pumps. Deck machinery consists of four Clarke Chapman double-barrel electric winches having a duty of 40,000 lb at 12·6ft per minute, or 20,000 lb at 25·2ft per minute from either barrel or both barrels together, and each powered by a 50 h.p. motor. Below deck are the fuel and fresh water tanks, store spaces and auxiliary machinery rooms. The equipment includes two 300 g.p.h. "Meco" water distillers, a "Mulsifyre" pressure tank system, and three 260kW B.T.H. 50 c/s alternators, coupled to 3·4kW d.c. generators, and each driven at 1000 r.p.m. by a twelve-cylinder vee-form Paxman-Ricardo diesel engine. There are six electrically driven pumps, each rated at 5000 lb per square inch at 1200 r.p.m., for powering the hydraulic system controlling the movement of the legs and the platform. Twin sets of hydraulic equipment are fitted to each leg and have rectangular pins which lock into the jacking bars for the lowering and raising movements and for holding. After the legs have been lowered to the sea bed the platform is raised to a specified height above the surface of the sea by the hydraulic units so that the structure climbs up the four legs, the speed of movement being about 16ft per hour, although this may be increased under favourable conditions. Upon the completion of drilling operations, the sequence of operations is reversed, the platform is lowered to flotation level and the legs retracted ready for the platform being towed to a new site.

The works of Steel Structures, Ltd., are situated at New Dock, Southampton, and the yard was laid out specially for the fabrication and assembly of unusual steel structures. One fixed and one travelling 10-ton, 120ft jib cranes serve the building berth, which has a reinforced concrete base laid on a heavily rolled foundation. The plate shop is equipped with edge preparation and profiling machines, a 500-ton hydraulic press and thick plate welding equipment and manipulators, together with a 20-ton overhead travelling crane. A 100ft jib derrick crane of 7-ton capacity covers the plate and angle storage area, and four movable shelters provide for continuity of outside welding operations.



Drilling platform shown raised and with legs lowered

Industrial and Labour Notes

Iron and Steel

British steel production in January averaged 358,200 tons a week which represents an annual rate of 18,627,000 tons, compared with an annual rate of 21,171,000 tons in January last year. Pig iron output in January was at an annual rate of 11,894,000 tons compared with 14,090,000 tons a year earlier. Commenting on the figures, the Iron and Steel Board says that, since the final quarter of last year, steel production has shown no further decline and is now running at 75 per cent of available capacity.

The Board adds that the experience of the different sections of the steel industry is in sharp contrast. The wide strip mills producing sheet and tinplate are operating fully, but the light product plants, making light bars and sections and narrow strip, are still in total operating at a low level although they show some improvement compared with a few months ago. The heavy steel makers, covering plates, heavy sections and rails, are still the most adversely affected. Provisional figures for the final quarter of last year indicate that deliveries of finished steel to consumers and merchants averaged 258,100 tons a week, or about 22 per cent less than in the comparable period of 1957.

The Employment Situation

The total number of people in civil employment in Great Britain at the end of December last was 22,875,000. That was 170,000 fewer than a month earlier, the principal reductions, according to the Ministry of Labour, being seasonal ones. The official statistics show that the biggest falls in employment during December occurred in agriculture, building and contracting and in the distributive trades. But in all the groups classified by the Ministry as the manufacturing industries, the labour forces were reduced. In the engineering, metal goods and precision instruments group, the labour force declined during December by 7000, making the total by the end of the month 2,792,000, compared with 2,857,000 a year earlier. In vehicle building, there was a drop of 2000, bringing the total employed to 1,222,000, compared with 1,245,000 at the end of December, 1957.

On January 12, there were 620,786 people registered as out of work, of whom 70,825 were temporarily stopped. Between December 8 and January 12 the number of unemployed increased by 89,000, the wholly unemployed rising by 70,000 and the temporarily stopped by 19,000. The Ministry of Labour says that, expressed as a proportion of the estimated number of employees, unemployment in January was 2·8 per cent ; it was 2·4 per cent in December and 1·8 per cent in January, 1958. The number of people registered as unemployed in Northern Ireland on January 12 was 45,700 (9·7 per cent) which was 6000 more than on December 8.

Restrictive Practices

Nearly three years ago, the Minister of Labour asked the National Joint Advisory Council to consider the question of " practices which impede the full and efficient use of manpower." The council is composed of representatives of the British Employers Confederation, the Trades Union Congress and the management boards of the nationalised industries ; its function is to advise the Minister of Labour on matters of concern to employers and workers.

The Council's report on its examination of restrictive practices was published at the end of last week. At the outset, of course, it was necessary to determine a basis upon which the review could best be conducted. The term " restrictive labour practices," the report says, is difficult to define. The most common sense, however, in which the term is used is in relation to those practices or extensions of practice which go beyond what is necessary for the reasonable protection of workers. The council was left in no doubt that there were in industry both practices and attitudes which could not in present circumstances be justified. Moreover, it considered that there was some tendency to perpetuate practices because they had been reasonable enough in the circumstances prevailing at the time of their introduction or because they were embodied in agreements. The council felt strongly that such practices should be subject to a new and searching examination to see whether, and to what extent, they still corresponded to the present needs of industry.

Inquiries were undertaken jointly by unions and employers' organisations and, as they progressed, it was found that the replies could be divided into three broad categories, as follows : (i) industries which had reported that they had no problems in regard to the efficient use of manpower ; (ii) industries which had set up machinery to deal with any problems or which appeared to be in process of doing so, and (iii) industries which needed more time, including those which, because of various difficulties, had been unable to undertake a joint examination. By the time the present report came to be prepared, information had been received in respect of 112 industries, sixty-four coming within the first category, forty-two in the second category and six in the third. The council says that it has been " a source of some satisfaction to learn that so many industries felt able to report that they were meeting no real difficulties in their efforts to ensure that manpower was efficiently used." But, it adds, the position is rather different in relation to those industries which have set up machinery to deal with any problems or which appeared to be in process of doing so. Whilst the existence of satisfactory joint machinery will give some measure of reassurance, much will depend on the use which is made of it in resolving problems which are likely to persist in at least some of the industries concerned.

Efficient Use of Engineering Manpower

In presenting the results of its inquiry concerning restrictive practices, the National Joint Advisory Council makes some special reference to the engineering industry. In the report (mentioned in the preceding note) it is stated that the engineering industry was placed in the second category " because of the machinery which the industry has long had for dealing with problems including those relating to the efficient use of manpower." During the early stages of its inquiry, the report continues, the Council had some misgivings about the position in the engineering industry where there appeared to be difficulty in getting under way the examination which had been requested. However, more recently the industry has informed the Council that it recognises the existence of difficulties, the solution of which require time and patience. At the same time, the industry has given an assurance that these difficulties are not regarded with complacency. An appendix to the report contains a statement prepared jointly by the Engineering and Allied Employers National Federation and the Confederation of Shipbuilding and Engineering Unions. This statement refers to the great changes in techniques, production methods, size of labour force involved and in the size of establishments during the last half-century which have been accompanied by an "almost incredibly small degree of friction." There is little doubt, the statement adds, that the changes which will take place in the industry will be at least as extensive as those which have occurred. Upon its ability to meet those changes will depend " not only the future of British engineering but also possibly the future of Britain itself."

Industrial Trends

The Federation of British Industries has published the results of its most recent inquiry into industrial trends. The information is based on replies received from 675 firms which were chosen as being broadly representative both of the different industries and the proportions of large and small firms constituting British manufacturing industry. The inquiry covered the four-month period up to the beginning of February.

The last investigation of this kind was made by the F.B.I. in October last year and the conclusion drawn from it was that the balance of opinion about the future had changed for the better. The Federation says now that this latest inquiry " suggests that there was some foundation for this change of opinion." The firms were asked, for example, if they felt more or less optimistic about the general business situation than they did four months ago ; 35 per cent replied that they felt more optimistic, 49 per cent replied " no change," 15 per cent said they were less optimistic, and 1 per cent made no reply. For the first time since the inquiry was instituted over a year ago, the number of firms reporting an increase in the rate of new orders over the last four months outweighs by a small margin the number reporting decreases. Improvement in the " new order " position, however, arises wholly in the home market, as, on balance, further declines have been experienced in new orders for export. Replies to a question about the numbers of people employed indicate a continued decline which is consistent with the latest figures from the Ministry of Labour, referred to in another note on this page.

As to capacity utilisation, 79 per cent of the firms which replied stated that their present level of output was below capacity. The F.B.I. deduces, however, that the general expectation of improvement in the future is about the same as it was four months ago. Expectations of future capital investment continue to show a decline, though to a lesser degree (particularly for plant and machinery) than four months ago.

Aluminium Alloy Footbridge in Natal

BY OUR SOUTH AFRICAN CORRESPONDENT

SOUTH AFRICA'S first all-aluminium alloy footbridge has recently been erected over the main South Coast Road, at Doonside, about 20 miles from Durban. This bridge, which is 156ft long by 6ft 6in wide, has eliminated a dangerous pedestrian crossing and is the first of a series of light alloy footbridges to be erected in Natal. Tenders for the second bridge have already been submitted to the Provincial Roads Department. The Doonside bridge, shown in Fig. 1, has been prefabricated in three 52ft spans of composite welded, riveted and bolted construction, and was erected in a matter of days. Each of the three units took only forty-five minutes to hoist into position. The photograph reproduced in Fig. 2 was taken shortly before the completion of the footbridge and shows the No. 12 gauge aluminium sheet, specially formed to an asymmetrical profile of high strength, used for the decking. This was later covered with an asphalt compound.

A specially developed structural alloy, B51 SWP, was used for all structural sections, the largest of which is the extruded load-bearing handrail-cum-channel. This channel section measures 6¼in wide by 4¼in deep, with the upper face curved to a 5in radius. This was produced in lengths of more than 20ft on the Aluminium Company of South Africa's 2200-ton extrusion press at Pietermaritzburg, and is one of the largest aluminium channel sections ever extruded in the Union. Rivets in A56S aluminium alloy and B51S alloy nuts and bolts were used for joining sections, and stainless steel foundation bolts to bolt the fixed and free ends to the concrete supports. All bolts, nuts and rivets were produced by W. G. Ramsey, of Pietermaritzburg. Argon tungsten arc welding was used with A56S aluminium alloy welding rod for joining gusset plates to horizontal members and in the fabrication of the supporting structure. Diamond mesh pignetting in aluminium alloy, produced by the Cyclone Gate and Fence Company, Ltd., of Pietermaritzburg, closes off the sides of the footbridge, making it completely safe—even for very young unescorted children. The use of aluminium alloy for a complete bridge is entirely new in this country, although the light metal has been extensively used for handrails and balustrades on many of the Union's highway bridges. The alloy was used in preference to steel or concrete, because footbridges built from the light metal can easily be removed in sections for erection elsewhere. This was of primary importance in the case of the Doonside footbridge, for as soon as the volume of traffic warrants the construction of a permanent highway bridge, it is to be removed and erected in another area. Other footbridges to be constructed in the series will serve a similar purpose. Other advantages in favour of aluminium include its ability to resist corrosion even in the severest of marine climates. This, of course, eliminates the otherwise necessary task of painting and other costly maintenance work.

The design and drawings for the bridge were given to Natal's Provincial Road Department by the Aluminium Company of South Africa, Ltd., while Dorman Long (Africa), Ltd., of Durban, was responsible for fabricating and erecting it.

S.A.A. "Viscounts" Fitted With Aluminium Alloy Galleys

SEVEN South African Airways "Viscount" aircraft are being fitted with aluminium alloy galleys made from extruded sections produced in the Union. This is a development of interest to the aluminium industry for it is the first time that South African-produced light alloy extrusions have been able to measure up to strengths that are normally only associated with special aircraft alloys manufactured overseas.

When ordering the "Viscount" 813 aircraft, the S.A.A. decided that standard galley equipment was unsuitable for use in this country owing to climatic and route distance factors. In addition, it wanted to equip the aircraft with galley units which would permit their own methods of operation and be able to accommodate standardised food storage containers in general use—something which the conventional "Viscount" galley could not do. Work began in March, 1957, and a very close co-operation was maintained with the catering branch of the S.A.A.

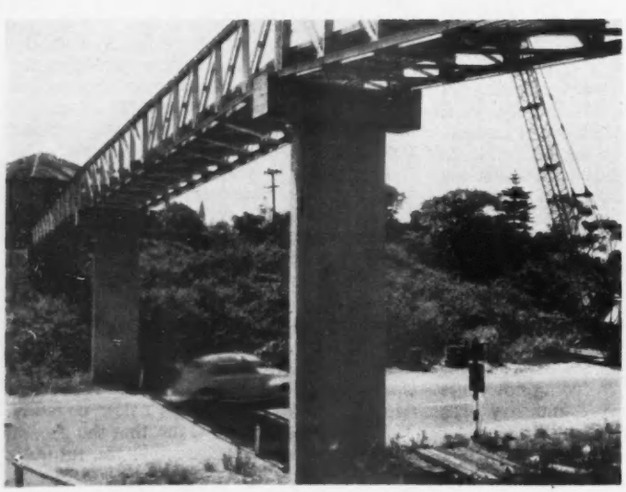
The new galley is positioned at the after end of the aircraft adjacent to the passenger compartment and the design of the equipment is such that the passage way between the main entrance door and the emergency exit—on opposite sides of the fuselage—is used as part of the working space.

The main galley units are fabricated from "Acosa" B51 SWP extruded angle sections, aircraft alloy sheet from the S.A.A.'s maintenance stocks and pressed board for the panelling of the cupboard doors. Units were pneumatically riveted throughout with 17ST alloy flush head rivets. The new galley is shown in our illustration. Once built, the prototype units were subjected to static load tests to ensure that the strength requirements of the British Air Registration Board and of Vickers-Armstrongs, the makers of the "Viscount," were met. These requirements included a forward load factor of 9 *g* and a downward load factor of 6 *g*. The first of these two factors was designed to simulate the conditions of an aircraft crash and to ensure that the galley units would not disintegrate.

The new galley is positioned at the after end of the aircraft adjacent to the passenger compartment. The design of the equipment is such that the passageway between the main entrance door and the emergency exit—on opposite sides of the fuselage—is used as part of the working space

The tests were carried out by applying suitably distributed weights on the structural members. In the case of the forward (crash) load condition, test weights totalling 4455 lb were used on the larger of the two galley units. No permanent distortion features occurred and all units passed the tests successfully, illustrating the high limits of strength that can be achieved and maintained by standard aluminium alloy sections produced by the Aluminium Company of South Africa (Pty.), Ltd.

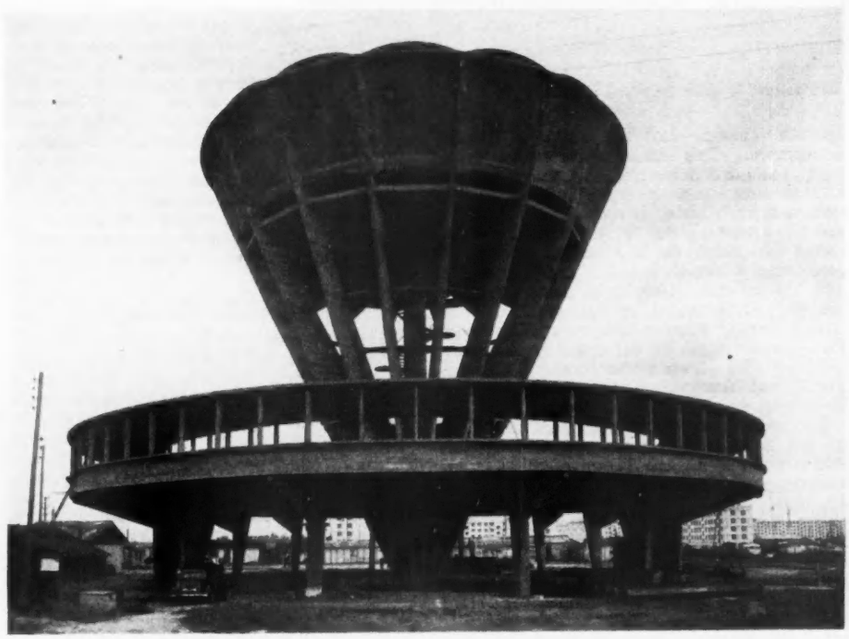
The decision to undertake the design, construction and fitting of component parts in the Jan Smuts Airport Workshops reflects the confidence of S.A.A. in the standard of workmanship that could be achieved and in the financial savings that could be effected.



Figs. 1 and 2—(Left) At Doonside near Durban an aluminium alloy footbridge was recently erected. It is the first all-aluminium bridge in South Africa. (Right) The decking sheet was specially designed to an asymmetrical profile; it was later covered with asphalt. The handrail is formed from extruded channel section

Water Tower at Caen—La Guérinière

IN the course of the post-war rebuilding of Caen, some 2200 dwellings are being erected by the public authorities in the southern suburb of La Guérinière, designed to accommodate about 10,000 people, in addition to which a large amount of private construction is being carried out. In consequence of the increased demand for water difficulties arose especially in the higher parts of the town on the right bank of the river Orne. Drops in the water pressure were particularly severe during periods of drought when the normal supply of 12,000 cubic metres per day dwindled to approximately one-third. Accordingly it was decided to construct a water tower which would allow the available supplies to be apportioned between the high and low pressure zones according to any desired schedule, and supply the high level zone at an increased head, while the low level zone would also receive water from the tower but with a lesser head. The arrangement for achieving this is of some interest and will be described later in this article.



The La Guérinière water tower is designed to supply a high pressure as well as low pressure system, and ensure adequate pressure even during periods of drought. In addition to its primary purpose, the structure provides accommodation for a market and, at first floor level, for a number of offices

As will be seen from our illustration, the reservoir takes the shape of an inverted circular truncated cone, and rests on sixteen equally-spaced columns which rise from the centre foundation in the direction of the generating lines of the cone. Horizontal extensions of these columns at first floor level stabilise the tower in a vertical direction. These beam extensions support a conical roof under which a market is to be installed. In turn, the beams rest on an elliptical ring of columns. A platform, cantilevered from the columns, carries a single-storey structure intended to house a number of offices of the municipality, a sub post-office and similar facilities. The building thus fulfils three functions, of which the two subsidiary ones have been ingeniously harmonised with the principal objective.

The horizontal extensions of the supporting columns are joined flexibly to the outer ring of columns on which they rest. Another series of flexible joints is provided at the base of the outer columns. The weight of the cantilevered portion of these columns, together with that of the superimposed offices, balances the outward force on the main columns together with the effect of wind pressure. Buckling of the very slender main columns is resisted by stiffener rings, the upper two of which are placed along the inner edges of the columns while the middle ring (just visible in our illustration through the office façade) extends across the whole column width. Before these rings were cast, the columns were prestressed by pulling them inwards by means of cables attached to opposite columns at the top and stressed to 4 tons per cable.

The centre of the tower is formed by a concrete column of approximately 1·6m outer diameter and 1·2m inner diameter in its upper portion. At the bottom, which is solid, the column broadens to 2·5m diameter. It is supported on a 7·7m diameter mushroom footing resting on limestone rock some 6·6m below ground level. Between this foundation and the centre column is a Freyssinet flexible joint which permits a tilting movement in any direction. This column supports the reservoir at the centre and acts as downpipe for the low pressure supply and overflow, separate free-standing 500mm diameter pipes being used for the rising mains and the high pressure outlet. In addition, the centre column carries an access spiral staircase.

The reservoir is a shell concrete structure with a reinforced concrete frame. The bottom rests on sixteen radial beams which are continued upwards as ribs at the outer edge along the line of the columns to which they are flexibly joined and of which they form the visual continuation. These ribs are interconnected by rings at the top and bottom respectively, which besides providing extra strength, proved to be of great value during construction by facilitating access to the top and supporting the side shuttering. In order to economise on the latter, the sides were formed using external shutter plates only and applying concrete by means of cement guns.

Altogether, the structure has forty-nine flexible joints, three at each column, and one in the centre. The principal data are listed in the table below.

TABLE—*La Guérinière Water Tower*

Gound level	30·57m sea level
Top of reservoir	62·53m sea level
Edge of reservoir roof	60·45m sea level
Diameter at roof edge	31·94m
Reservoir bottom level	54·70m sea level
Top of columns	51·70m sea level
Top of joint between columns and centre	38·57m sea level
Lower edge of beams over market	35·57m sea level
Bottom joints in outer columns	30·40m sea level
Joint in central column	27·65m sea level
Central mushroom footing	23·95m sea level
Diameter of central footing	7·70m
Outer columns set on ellipse with major axis	40·26m
minor axis	34·32m
Overhang of outer cantilever platform	5·00m
Total weight (including water), (approx.)	5000 tonnes
Ground pressure at central footing (approx.)	10 kg per square centimetre
Volume of concrete, (approx.)	1200 cubic metres
Shuttering (total, approx.)	15,000 square metres
Steel reinforcements (approx.)	150 tonnes
Design wind pressure, at height	
25m	85 kg per square metre
15m	75 kg per square metre
10m	65 kg per square metre
Resulting moment of wind force	940 tonne-metres

It will be seen from these figures that a great economy of concrete and reinforcement steel was achieved. As reinforcement, "Tor" steel was used which gives improved bonding and obviates the need for turned-back ends. Design stress for the concrete was 72 kg per square centimetre, for which the regulations prescribe a test cube strength of 260 kg per square centimetre at 90 days; this was in fact exceeded and 320 kg per square centimetre in 28 days was reached. Higher stresses were used at the joints.

The comparatively large size of the reservoir is accounted for by the fact that its water is destined for the two supply zones, at high and low level, between which it is shared out, as stated. Had the purpose of the reservoir been merely to provide increased pressure for one area, namely the high level zone, its volume could have been much less.

From the rising main, the incoming water reaches a weir fitted with a splitting plate by which the division of the flow between the two systems is accomplished. The "high pressure" flow goes into the reservoir from where it is withdrawn by a 500mm diameter downpipe. The "low pressure" flow enters the central pipe, as does any overspill water. Since the water level in the central pipe varies between 30m and 49m sea level, the water if allowed to cascade into this pipe would entrain air which could cause trouble in the distribution system. To obviate this, the inlet was arranged to give a spiral inflow, so that the water descends in a helical path at an angle of 1 in 5, being held to the pipe wall by centrifugal action. In this way, very little air is entrapped and any such air can rise and escape up the centre of the vortex. The reservoir is prevented from overflowing, in case of serious unbalance between inflow and withdrawal, by a shut-off disc valve equipped with a float, and arranged so as to give a very gradual closure and avoid water hammer.

The water tower was designed jointly by Messieurs Guillaume Gillet, architect, René Sarger, consulting engineer and head of Bureau C.E.T.A.C., Bernard Cayla, assistant architect, and J. P. Batelier, assistant consulting engineer.

Time Signalling Synchronous Clock

In factories and yards the beginning and end of working periods are indicated by signals from bells or hooters. A device which puts into operation a seven-day programme of such signals is being produced by Siemen and Halske A.G., Berlin and Munich. This programme controller utilises an endless punched paper tape with markings for seven days and up to five different circuits. A signal can be given every fifth minute. The controller is either driven by an existing synchronous clock, or can be supplied built into a special synchronous clock for connection to 110V/125V or 220V, 50 c/s mains. The clock is self-starting, and interruptions in the supply are indicated by an acoustic or optical signal. The five signal circuits can operate on d.c. or a.c., and the signal duration can be varied between five and fifteen seconds.

The viaduct over the River Esla, north-west of Zamora, is 481m long and 84m high

Zamora–La Coruña Railway

With the inauguration on September 10, 1958, of the final section of the railway line from Zamora to La Coruña, between Carballino and Santiago, another chapter has been concluded in the history of the Spanish railways, and an important contribution to communications in the north-west of the country has been achieved. The project went through a great many vicissitudes which at times must have seemed to prevent its realisation altogether. First mooted in 1860, the idea of a railway through this corner of the mountainous province of Galicia did not take concrete shape until 1910. By 1913 a definite project had been elaborated, but it took another fourteen years before work could actually be commenced, only to be paralysed in 1932 by the economic crisis. Then came the Civil War of 1936–39.

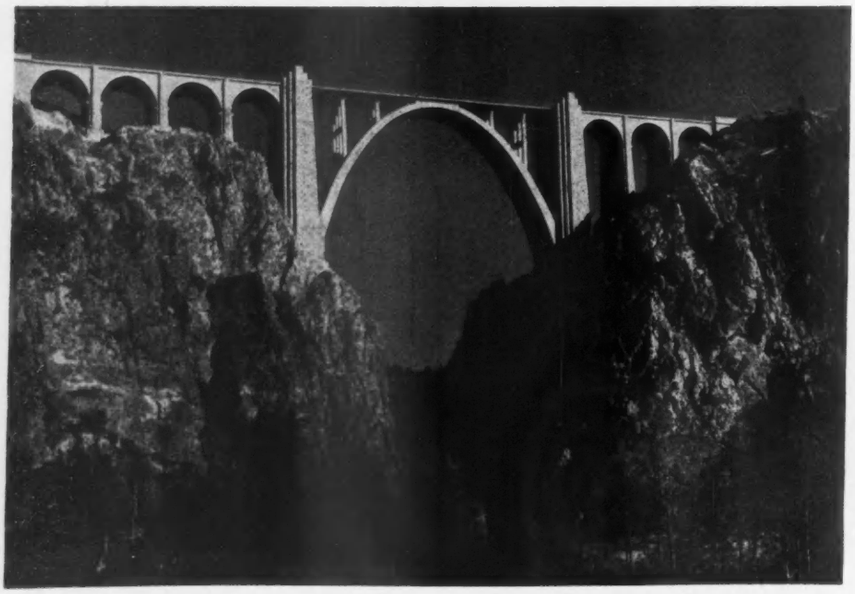
Then the Zamora–La Coruña project was revived, and the first stage was eventually completed in 1943. This comprised the 74km of line from Santiago to La Coruña, involving the construction of nineteen tunnels from 40·5m to 1828m long and totalling 8260m, or over 11 per cent of the line. The same year saw the completion of the viaduct over the river Esla, (illustrated above), which the railway crosses between Zamora and the centre of Puebla de Sanabria. This section of 106km was eventually inaugurated in 1953. Between Zamora (292km north-west of Madrid) and Puebla (398km from Madrid), it runs along the north-easterly corner of the frontier with Portugal, across the Sierra de la Culebra. Here, the percentage of tunnels is lowest and amounts to only 1·8 per cent. Only seven tunnels, ranging between 152·5m and 428m were required. The most important stucture here is the Esla viaduct with a total length of 481m and a maximum height of 84m. Two further viaducts, those of Vertillo and Truchas, are respectively 212m and 280m long, and 28m and 47m high.

The greatest difficulties presented themselves on the next stage, the mountainous section Puebla–Orense. Of the 142km of this section, no fewer than 30·26 per cent consists of tunnels. The eighty-eight tunnels vary between 82m and 5949m (Túnel de Padornelo). Some of the most difficult work lies on the first 37·5km between Puebla and La Mezquita, including the tunnel just mentioned, two important earth embankments, and two further long tunnels, of 1713m and 2008m lengths. This section, together with the additional 30km to Carballino, was inaugurated on July 1, 1957.

The third section along the line from Madrid, that from Orense to Santiago del Compostela via Carballino, Irijo, Lalín, and Silledra, is 130km long. Its most important tunnel is the 2606m long Fojo del Cabrito tunnel between Irijo and La Gesta, its most important viaduct the 219m long and 86m high bridge over the river Ulla (illustrated). This part of the railway has sixty-eight tunnels, which together make up 16·39 per cent of the track length, and nine important viaducts.

On the whole 452km of the Zamora–La Coruña railway there are thus 163 tunnels, totalling nearly 74·3km, or 16·38 per cent. There are also fourteen viaducts totalling 2671m. Between Zamora at 638·3m sea level and La Coruña on the Atlantic coast, the line ascends to just over 1100m in the Sierras and then descends to 133·5m at Orense, only to ascend again to 584·2m (in the Fojo del Cabrito tunnel), and to descend towards Santiago (220m). From there to La Coruña the level fluctuates, rising to a maximum of about 340m.

Throughout, gradients are limited to a maximum of fifteen per thousand, and the minimum radius of the curves to 400m. The structures were designed for two tracks. The line is of standard broad gauge (5ft 6in) with rails of 45 kg per metre. All level crossings have been avoided. An underground telephone cable has been laid along the track, and a power transmission line for the exclusive use of the railway has been installed. The opening of the new line shortens the rail distance between Santiago de Compostela and Madrid by 242km. It will greatly assist the economic development of southern Galicia, in respect of its agriculture and forestry, as well as help to exploit its mineral wealth, such as the deposits of lithium, tungsten, iron and tin which are found in the vicinity of Lalín.



Ulla viaduct (219m long, 86m high), between Bandeira and Vedra Ribadulla, on the line Orense–Santiago

AGARD Meetings

From February 2 until February 7, the Materials Panel of AGARD (Advisory Group for Aeronautical Research and Development of the North Atlantic Treaty Organisation) held a meeting in Washington, D.C. The following further meetings will take place in the first half of 1959 :—The Wind Tunnel and Model Testing Panel will discuss " Interference Effects in Aerodynamic Test Facilities " (Brussels, March 2 to 5) ; the Materials Panel and Structures Panel will meet in Paris (April 13 to 18 and 20 to 25, respectively), and there will be a meeting in May of the Ionospheric Committee. A joint meeting of the Aeromedical Panel and the Flight Test Techniques and Instrumentation Panel will be held in Athens (May 11 to 15) on " Medical and Human Engineering Aspects of Flight." Structures fatigue and full-scale testing will be discussed in Amsterdam, June 7 to 9.

The Combustion and Propellants Panel is organising an unclassified meeting on " Chemistry of Propellants," to take place in Paris during the period June 8 to 12. The meetings will be held in the NATO Headquarters Building, Palais de Chaillot, Paris (16*e*). It will provide critical reviews of the state of knowledge in the propellant field and give guidance on problems and problem areas in this field requiring increased research and development effort, in particular, assisting those laboratories and institutions wishing to inaugurate modest research programmes.

The last day will be devoted to a ound table discussion on " Basic Problems in Propulsion " by recognised authorities in the special fields of solid propellant rockets, liquid propellant rockets, composite launching devices nuclear propulsion, ion propulsion, and plasma propulsion.

French Shipbuilding

During 1958, French shipyards laid down the keels of fifty-six ships of 563,728 gross tons, of which oil tankers accounted for fourteen ships of 361,155 tons. A total of sixty-two ships of 434,427 gross tons, including thirteen oil tankers of 256,081 tons, were launched ; the completions amounted to seventy ships of 429,010 gross tons, which included twelve oil tankers of 229,661 tons, representing 53·4 per cent of the total tonnage ; cargo ships represented 39·5 per cent, ore carriers 3·1 per cent, and small craft 2·9 per cent.

Wagon for Semi-Trailer Transport

Under the name "Kangaroo Wagon," the firm Société Lorraine des Anciens Etablissements De Dietrich et Cie, Lunéville (Head Office : 3, Avenue du Président Wilson, Paris, 16°) is producing a railway wagon for carrying semi-trailers up to and including the largest sizes in current use. In the accompanying illustrations we show this design which, it is stated, will come into regular service with the S.N.C.F. in June.

According to the maker, the principal advantage of the wagon is that it utilises to the full the available loading gauge, so that trailers can be accommodated with the maximum width allowed by law of 2500mm and maximum height, from the road to the crown of the rounded roof, of 3954mm. Only three, comparatively minor, alterations are required to adapt a standard semi-trailer for use with a "Kangaroo" wagon. A special ball socket has to be fitted to the front end to serve as an auxiliary attachment for the tractor during manœuvring ; the single or double rear axles have to be fitted with special wheel rims equipped with a flanged railway tyre between the two pneumatic tyres. In addition, the number plates at the rear of the trailer must be capable of folding forward into a horizontal position. Depending upon the size of vehicle, all these modifications are estimated to add only between 60 kg and 100 kg to the weight.

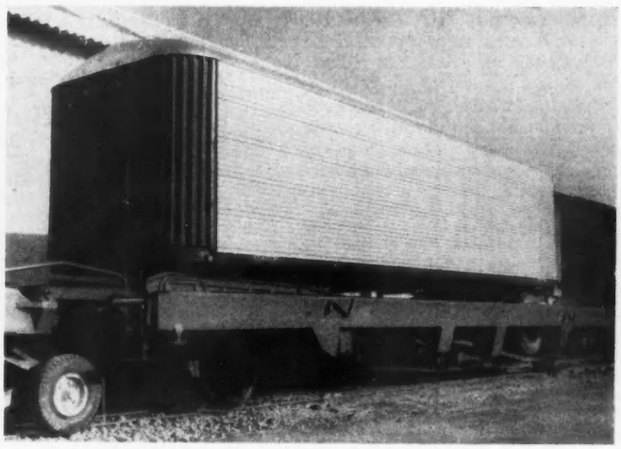


Fig. 1—"Kangaroo" transporter wagon carrying a 50 cubic metre semi-trailer. A drawbridge ramp allows the trailer wheels to be lowered as shown, or, alternatively, forms a horizontal track for manœuvring the trailers along the train into and out of position

After a train of "Kangaroo" wagons has been made up, the semi-trailers are loaded with the help of a special tractor, using a fixed or mobile ramp.

Our second illustration shows an end view of a mobile ramp attached to a wagon. As may be seen, both ramp and wagon deck have flat tracks on either side for pneumatic tyres, with a raised rail running along the centre of each track. The double rear tyres of both the tractor and semi-trailer run on either side of this rail which engages with the central steel tyre, thus guiding the assembly along the wagon. The tracks on each wagon are hinged at the front ends, and when unloaded can be winched up or down by hand at the rear end. With the track in a horizontal position, the deck can be traversed by the trailer-tractor combination, which by means of folding bridge pieces connecting the wagon decks can be backed over the length of the train on to the last free wagon. On this wagon, the tracks have been lowered at the rear end with a 13·3 per cent gradient forming pockets for the wheels, with a cross beam of the wagon frame acting as a stop. In this manner much overhead room is gained, so that trailers of 25 to 29 tonnes total weight (depending on whether they are single- or double-axle) and 50 cubic metres useful capacity can be loaded. When the trailer has been positioned on the wagon, the tractor sets down the front end and disengages itself. This brings the trailer body into a horizontal position just above the wagon deck. The front end of the trailer is locked in place by a pin.

The length of the "Kangaroo" wagon is similar to the No. 2 Standard flat deck wagon, 13·70m over buffers and 12·52m over chassis. It is a twin-axle design of 9m wheelbase, fitted with wheels of 1m diameter, and has a tare weight of 11 tonnes. The mobile loading ramp is 12·35m long, and is fitted at the high end with two axles, one a railway wheelset, the other equipped with pneumatic-tyred wheels.

Fig. 2—Mobile loading ramp attached to transporter wagon. The illustration clearly shows the rails on both ramp and wagon which keep the trailer and tractor in alignment

Ultrasonic Drilling Equipment

An ultrasonic drilling machine and generator developed by Apparechi Scientifici Frederici, of Milan, were exhibited in London recently by Airmec, Ltd., High Wycombe, Bucks, the sole agent in the United Kingdom for the Italian company. This machine was one of a range with ratings between 200W and 1600W. In another series, extending up to 3200W, the transducer and tool are mounted on a support similar to that used for milling machines (see illustration), with a carriage movable in three directions.

The complete equipment shown consists of an ultrasonic power generator which feeds a magnetostrictive transducer housed in a sealed container into which the tool is inserted. A wide variety of operations can be carried out on hard materials, such as glass, porcelain, quartz, stainless steel and tungsten carbide. The machine may also be used to finish holes of large dimensions which have been made by electric erosion or electrolytic methods. Its scope is defined by the maker as the working of pieces normally regarded as exceptionally difficult and expensive to machine, either because of the hardness of the materials or because of the complex shapes required.

The magnetostrictive transducer is mounted in a manner which allows very sensitive vertical movements to be obtained for exerting a controllable pressure. Drilling is achieved by the use of an abrasive material suspended in liquid to form a slurry which is interposed between the tool and the workpiece under pressure and is subjected to ultrasonic vibration through the tool. A complete circulation system, comprising pump, filters and tank, is provided for the abrasive. A second pump is used for circulating cooling water.

Ultrasonic drill with milling head, electronic generator, and (visible between the units) the pump for circulating abrasive

Operational frequency of the electronic generator is variable between 20 and 30 kc/s by a panel control to suit different tools and to compensate for the effects of initial oscillator temperature changes and of the material with which the tool is in contact. A power output control allows the energy supplied to be limited in the early stages of drilling to protect fragile workpieces or slender tools. The output is indicated on a meter. Other controls are a heater switch, which also brings the oscillator and pre-amplifier stages of the generator into operation, and a h.t. switch which applies h.t. to the power amplifier anodes after a thermally imposed time delay.

Oxygen Lime-Powder Steelmaking Process

The process of steelmaking by the O.L.P. (oxygen, lime-powder) method developed by the French Iron and Steel Research Institute (IRSID), is now in current use as a commercial process at the Denain Works of the USINOR Steel Company. It is stated that this works has already satisfactorily produced over 10,000 tons of steel by this technique. The product is claimed to be fully equivalent to high-grade open-hearth steel. Extensions to the USINOR equipment are in hand to increase production by this method. After years of study, IRSID were the first to produce steel by blowing molten pig iron with lime-powder in suspension in pure oxygen and to publish their findings. A series of patents on this process* has been filed in France and other countries. On account of the flexibility of adapting this process to pig irons of widely different compositions, several French and foreign steel companies are stated to be showing keen interest in what promises to become a very important development in steelmaking.

Council of Europe Research Competition

A competition with a prize award of 1,000,000 French francs is announced by the Secretariat-General of the Council of Europe. The prize is to be awarded every two years for a thesis on a given subject of European importance. For the first competition the subject chosen is "Consequences of the use of nuclear energy for the European mode of life." Further information may be obtained from the Secretariat-General, Council of Europe, Strasbourg, France.

* The method is described in *Revue de Métallurgie*, December, 1958, which contains references to earlier papers. See also B. Trentini, L. Wahl and M. Allard, "Desulphurisation of liquid pig iron by blowing with lime powder," *Journal I. & S.I.*, May, 1956, and *Revue de Métallurgie*, June, 1956.

Ravenswood Works of Kaiser Aluminum, West Virginia

BY OUR AMERICAN EDITOR

The integrated aluminium smelting and rolling mill facility of the Kaiser Aluminum and Chemical Corporation at Ravenswood, West Virginia, is considered to be an outstanding example of modern American engineering and production practice in the light metals field. The new plant has an annual capacity of 145,000 tons of primary aluminium and 170,000 tons of rolled sheet, plate and foil. Unlike earlier aluminium works, Ravenswood is situated in a major coal-producing area of America and depends on steam-electric generation of power. The alumina reduction plant and rolling mill are adjacent to each other, and hot metal is transferred between them by large crucibles.

WITH the Ravenswood Works of the Kaiser Aluminum and Chemical Corporation having gone into full operation recently, a major integrated aluminium producing facility has been added to the American light metals industry. After starting its industrial operations on the West Coast, Kaiser Aluminum has been moving eastward for nearly ten years. When Henry J. Kaiser entered the aluminium business in 1946, he started with a "package" of three Government-built works that comprises an almost completely integrated aluminium system. The alumina plant at Baton Rouge, Louisiana, could produce 500,000 tons of alumina annually. The smelter at Mead, Washington, had a capacity of 108,000 tons of primary aluminium per year—about 17 per cent of the total American capacity at that time. Finally, the large rolling mill at Trentwood, Washington, could turn out some 144,000 tons of rolled products a year.

These works were leased in 1946, and bought by Kaiser Aluminum in 1949. Having been constructed during World War II they were modern and in good running order. Kaiser had the nucleus of a management team ready to take over, and the big post-war boom in aluminium consumption was then beginning. But there were weaknesses. In particular, the company lacked its own ore reserves. Also, the product mix at Trentwood, a single-purpose aircraft sheet rolling mill, was too limited. Finally, Kaiser's producing units were on the West Coast, far from the big Eastern and mid-Western markets.

The first deficiency was remedied in 1950, when Kaiser Aluminum bought 4600 acres of bauxite-bearing land in Jamaica and took options on additional acreage. Starting in the same year, Trentwood was converted into a complete specialty mill. Its capacity was eventually increased to 200,000 tons and its product range was broadened by the modification of existing facilities and the installation of new equipment. But it was in the correction of the third weakness that Kaiser Aluminum has made its most important moves. In the course of one of industry's most ambitious expansion and diversification programmes, the company has multiplied by many times its capacity to produce and fabricate aluminium, broadened its product mix to include virtually all aluminium mill forms and established a firm foothold in the lucrative Eastern and mid-Western markets.

Site Selection and Power Sources

The choice of Ravenswood, West Virginia, on the Ohio River, as the site for a new integrated aluminium smelting and fabrication works is of much interest since it indicates a significant change of economic policy. Most previous such works, both in the United States, Canada and in Europe had been based in close proximity to hydro-electric power facilities, going back even to the historical Pechiney works at St. Jean-de-Maurienne in the French Alps. By placing the new works in West Virginia, Kaiser Aluminum will depend entirely on the steam-electric power generating facilities of the Ohio Valley, which, in turn, depend on the coal resources of this area.

Coal is to West Virginia's history and development what gold has been to California and oil to Oklahoma. Forty-nine of the fifty-five counties of the state have coal under them in more than 100 different seams; forty-two of them are more than 3ft thick. It is estimated that there are more than 50,000 million tons of coal underlying the state; only a little over 3000 million tons have been removed. There may be enough reserve in the Ohio–West Virginia coal complex to last for 1000 years at current rates of consumption.

The seams are reached through four kinds of mines; drift mines, where the mass of coal is reached horizontally on a level grade; slope mines, where the coal is reached by tunnelling at a perceptible angle; shaft mines, where a vertical shaft strikes down to the seams; and surface mines where the coal is reached by removing the overbearing of rock. The degree to which the coal can be extracted, cleaned and transported at competitive costs has been a measure of the state's economic well-being. In 1900, the average production of coal per man-day was 3·17 tons; by 1945 it had doubled to 6·24 tons; by 1957 it had tripled to 10 tons.

Most of these economies have come about through an improvement of mining equipment. In surface mines, enormous overburden stripping shovels have been developed. Equal improvements have been made in underground mining with the development of the continuous mining machine. In addition to improving mining efficiency, coal producers have worked hard at cutting transport costs. Transport constitutes 40 per cent of the delivered price of coal. One obvious solution has been to lure the coal users closer to the mines; another has been to build pipelines through which the coal can be pumped; still another has been to connect mine and user with conveyor belts, and some, like the American Electric Power Company, have moved not the coal itself, but the electrical power it can generate, by improved methods of high-voltage transmission.

One coal pipeline in eastern Ohio is capable of moving 1,200,000 tons of coal per year. Specially prepared coal is crushed and mixed with water to form a slurry, which is then propelled by pumps through the pipeline. A 4½-mile conveyor belt now carries coal at the rate of 800 tons an hour from a surface mine to the Ohio Power Company's 880MW Muskingum River station, one in the complex of plants that feeds power to the Ravenswood Works. Because of all these economies, "King Coal" has come back into his own again in West Virginia and in adjoining areas, thus facilitating the creation of a large aluminium works in the Ohio Valley.

Until a few years ago, virtually all aluminium production in the United States was based on cheap hydro-electric power. Producers traditionally "went into the brush," far from consuming markets, to place their works near sources of hydro-electric power. A change in attitude came during the Korean emergency when several new reduction works—including Kaiser's Chalmette works near New Orleans—were built adjacent to natural gas fields. But as still more capacity was needed, the producers began looking for still another source of power. There is always the risk that the price of natural gas power could be bargained up by other users who could afford to pay higher rates. Coal-based power had been under consideration for some time, but it was not until advances in coal mining and steam-electric generation techniques had reduced the cost of such power that Kaiser and other producers elected to use coal-based power. All of the Ravenswood Works' power needs—2400 million kWh per year—are supplied by the Ohio Power Company, an operating subsidiary of the American Electric Power Company. The power agreement, one of the largest ever arranged between two private companies, calls for the availability of 450MW of firm power, around-the-clock, for forty years. Kaiser Aluminum has not revealed what it is paying for power, but the cost of gas-generated power is now almost in line with that of coal-based power. Hydro-electric power is still cheaper, of course, but the greater freight factor probably cancels out this advantage.

The Ravenswood Works, with an ultimate annual capacity of 145,000 tons of primary aluminium and 170,000 tons of sheet, plate and foil, constitutes Kaiser Aluminum's bid for a major part of the largest market for aluminium mill products. Within 500 miles of Ravenswood are some 16,000 works that account for approximately 80 per cent of the consumption of aluminium sheet, plate and foil in the United States. Before the creation of Ravenswood, Kaiser had to transport these products all the way from Trentwood, paying the price of a trans-continental haul in many cases, and suffering the disadvantages of longer delivery times to

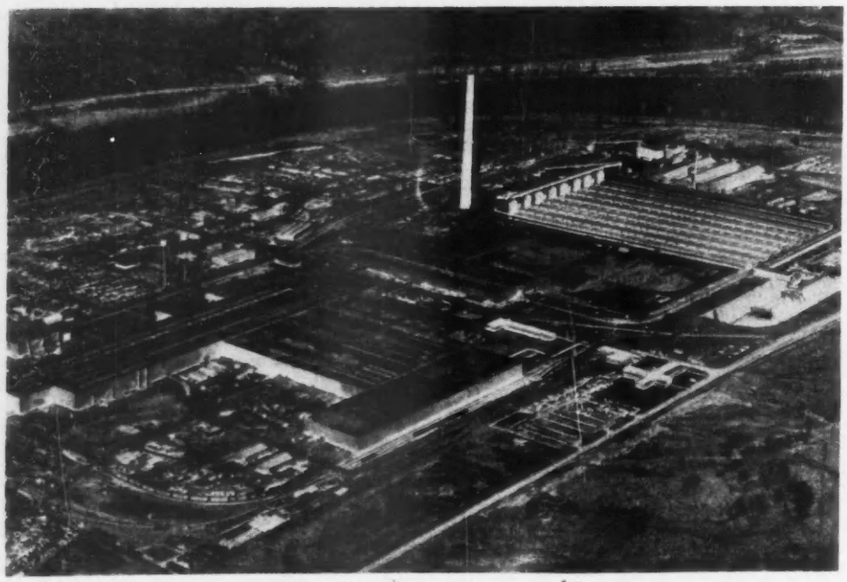


Fig. 1—Aerial view of the Ravenswood Works, with the Ohio River in the background, the reduction plant at the right and the rolling mill plant at the left

important customers. Its competitors, on the other hand, had major rolling mill facilities strategically situated in or close to the East-Midwest marketing area. But with the Ravenswood Works, Kaiser Aluminum can now readily face its competitors. The central location of the new mill cuts shipping costs all the way from ore to delivered sheet, for the Ravenswood Works completes one of the most efficient "mine-to-mill-to-market" operations in the metals field.

For the ultimate in low-cost shipping, Kaiser Aluminum can now use cheap water transport all the way—bauxite in ore boats from Jamaica to the alumina plants on the Mississippi River; and alumina on barges up the Mississippi and Ohio rivers to Ravenswood.

Reduction Works

Metal tapped from the reduction cells is carried in the molten state to the casting bay where it is alloyed and cast into rolling ingots. Here, obvious economies are the elimination of one melting operation and the reduction of shipping costs. Of perhaps equal importance are the more efficient scheduling of production and the closer control of quality achieved with this integration of the smelting and rolling operations. Not the least of Ravenswood's advantages are the plant and equipment themselves. Any new works may reasonably be expected to embody the latest and most efficient equipment and production techniques, and Ravenswood is no exception. Throughout both the reduction works and the rolling mill, the emphasis is on an automatic handling of materials. In the anode rodding room, for example, an elaborate conveyor system attaches and removes parts from the reduction cell anodes mechanically, in contrast to the conventional manual system.

Each of the four potlines consist of two potrooms, 1170ft long and 54ft wide, and each potroom contains eighty-two reduction cells. Each 10ft by 20ft prebake type cell is connected in series and is designed for 80,000A operation and 4·7V drop per cell. Each cell operates at over 1700 deg. Fah. and produces more than 1000 lb of aluminium every twenty-four hours.

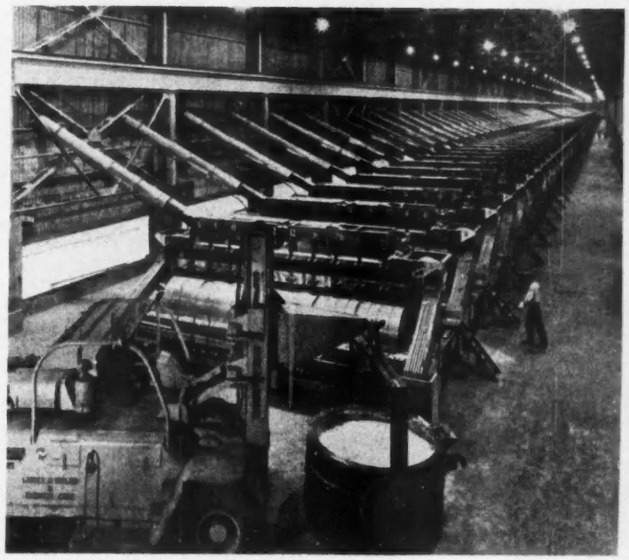


Fig. 2—One of the eight potrooms of the reduction plant, with eighty-two cells, showing transfer crucible and fork-lift truck in the foreground

Each pot is tapped about once a day; the molten aluminium is syphoned into 8000 lb capacity crucibles which are carried by special lift trucks. When a crucible is full, the lift truck transports it through a quarter-mile long covered passageway to the casting room of the rolling mill. Before the crucible leaves the smelter, however, samples of the melt are despatched by pneumatic tube to the laboratory for analysis by a direct-reading quantometer. Results are reported by teletype within a few minutes, often before the crucible reaches the casting shop. This arrangement aids in directing the metal to the proper alloying furnace.

Ingot Production

The casting shop has six melting-holding-casting stations. Each consists of a round, gas-fired, top charging melting hearth with a capacity of 65,000 lb, a 35,000 lb capacity holding hearth, and a direct-chill casting station. The alloying of the metal takes place in the "Swindell-Dressler" melting hearths, which operate at a temperature of 1250 deg. to 1370 deg. Fah. After alloying, the metal is transferred directly to the adjacent "Swindell-Dressler" holding hearths, from which it is fed to one of the six "Loma" direct-chill, hydraulically-operated, semi-continuous casting machines. Two 10,000 lb rolling ingots or more smaller ingots may be cast at one time on each of these machines. Representative ingot sizes are 16in by 34in and 16in by 44in, cast in any length up to 180in. The time of pour is up to one hour per drop. To ensure proper alloy content, quantometer analyses are made while the metal is in the holding hearth and while it is being poured in the casting moulds. Again, the results are swiftly relayed by teletype. The casting shop also has two conveyor-type casting machines for casting 50 lb pigs and a machine for casting 1000 lb "sows."

However, most of the metal is cast into rolling ingots, weighing up to 5 tons each. These are taken by overhead crane to the adjacent scalping shop, where the first American duplex scalping machine has been installed to remove the as-cast surface metal from each side of the ingot simultaneously. Built by the Consolidated Machine Tool Division of Farrell-Birmingham, this machine can scalp a 5-ton rolling ingot in about one and a half minutes floor-to-floor time. It will handle ingots measuring from 8in to 16in thick, 30in to 45in wide, and 6ft to 14ft long. The 75in diameter cutters, each driven by a 1000 h.p. motor, rotate at 600 r.p.m., and remove as much as $\frac{1}{2}$in of metal from each side of the ingot. The scalping chips drop into a shredder below the machine which cuts them into short pieces and feeds them to two conveyor systems which carry the scrap to a salt bath melting furnace. Here, the chips are melted and cast into "sows."

The scalped ingots are then ready to be pre-heated and rolled. Pre-heating takes place in a battery of twenty-four soaking pits built by the Surface Combustion Corporation. Each pit can hold from sixteen to twenty-four ingots, depending upon size. The pre-heat temperatures, ranging from 800 deg. to 1175 deg. Fah., are maintained by a combustion system consisting of a radiant tube air heating chamber, bottom heat radiant tubes, a combustion air blower, and dual circulating fans. A gas burner is situated at the inlet end of each radiant tube.

Hot Rolling

At Ravenswood, in less than six minutes, an aluminium ingot measuring roughly 10ft long, 4ft wide and 15in thick is converted into a coil of $^{1}/_{10}$in thick sheet weighing up to 5 tons. In its travel down the $\frac{1}{4}$-mile long tables, the metal passes through three major pieces of rolling mill equipment with a total value approaching 26,000,000 dollars. Initially the ingot encounters the 42in vertical edger. This rolls and conditions the sides of the ingot to obtain proper edge quality and shape. A run of 37ft then takes the ingot to the entry side of the "United" 168in, four-high reversing hot mill.

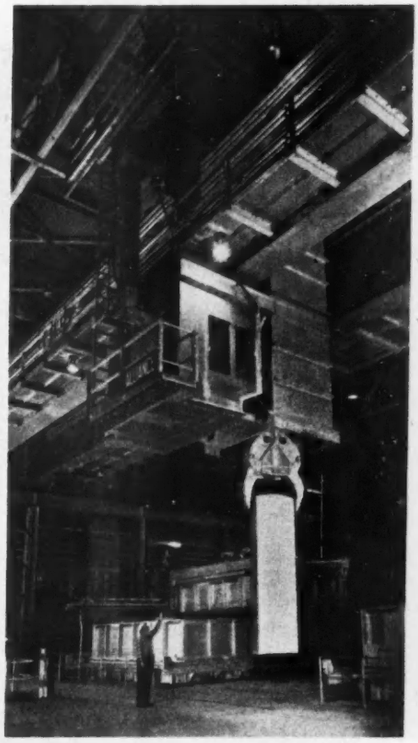


Fig. 3—Transfer of continuously cast 5-ton ingot from casting shop to soaking pits of hot rolling mill

Described by Kaiser Aluminum as "the largest and most perfectly proportioned and most highly automatic aluminium rolling mill in use anywhere in the world," this machine reduces the 15in thick ingot to a slab approximately 4in thick. The ingot is first rolled broadside to impart the proper width, then turned lengthwise and rolled longer by several passes through the mill. A maximum opening of 24in is provided between the 38in diameter work rolls. The backup rolls are 60in in diameter, and power is supplied by two 5000 h.p. motors. The breakdown mill operates at speeds of 30ft to 600ft per minute, and is capable of reversing from full speed ahead to full speed reverse or vice versa in four seconds.

An important aspect of the mill is an automatic screwdown control. If the operator wishes to repeat a given rolling sequence, he records the various mill settings used to roll the first ingot, then transfers these settings to a plastics punch card. The card is inserted into the pick-up mechanism of the automatic screwdown control whenever that sequence of operations is called for. The operator activates the mill for each pass, but the automatic screwdown control makes the actual settings. Although normal operations require only six or seven passes for each ingot, some higher aluminium alloys require as many as twelve passes.

The 4in thick slab rolls down the table towards the next mill, passing through a 6in down-up-cut shear which trims the ends square. If needed, bell type reheat furnaces are available at this stage to bring the slab back to rolling temperature. The next rolling operation is performed by the "Loewy" 110in reversing intermediate mill. After passing through a 38in vertical edger, the 4in thick slab enters the intermediate mill and is reduced to 1in thickness. This mill operates at a maximum speed of 600ft per minute. A maximum opening of 16in is provided between its 39in diameter work rolls. The backup rolls are 60in in diameter, and power is provided by a 6000 h.p. motor.

Finally, the aluminium slab—now about 1in thick and roughly 175ft long—passes through the "United" five-stand 100in tandem mill. Initially, a 3in scrap shear squares the slab ends; then the slab enters the first stand of the

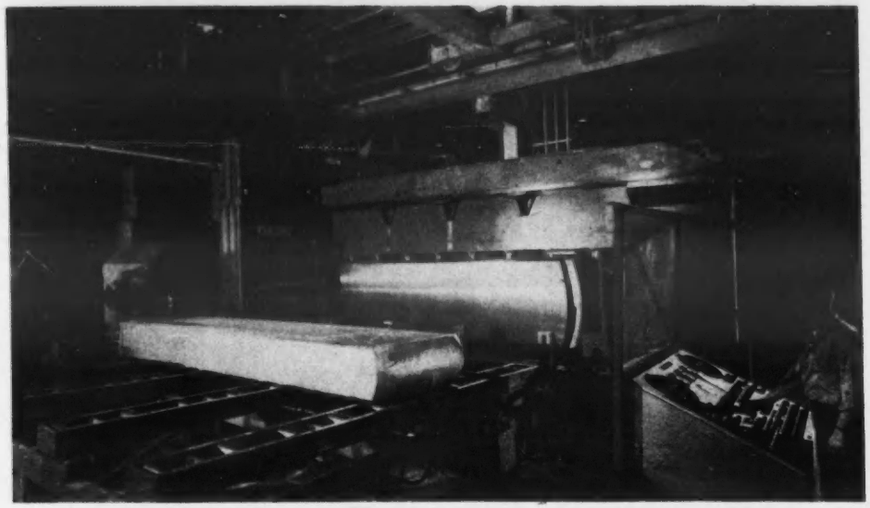


Fig. 4—Farrell-Birmingham duplex scalping machine capable of milling both sides of a 5-ton rolling ingot in only 1½ minutes

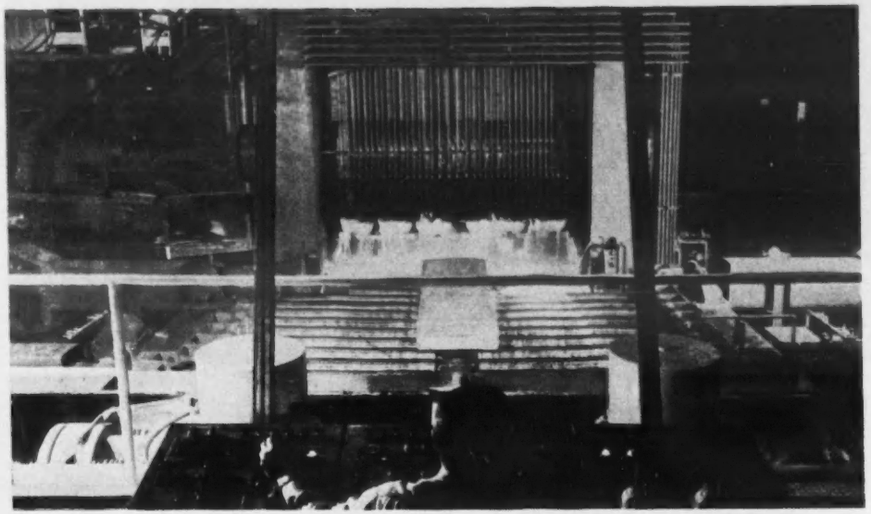


Fig. 5—United 168in reversing four-high breakdown mill with 42in vertical edger and automatic screwdown control

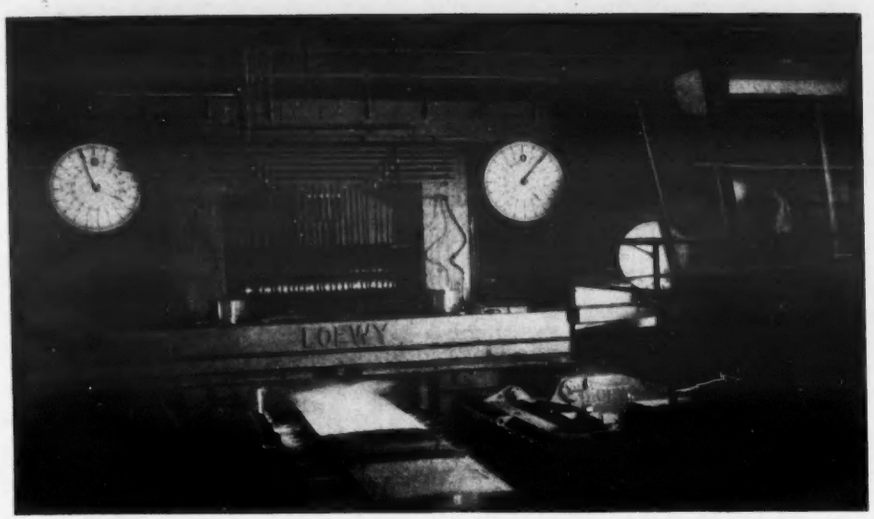


Fig. 6—Loewy 110in reversing four-high intermediate mill with 38in vertical edger and automatic screwdown control

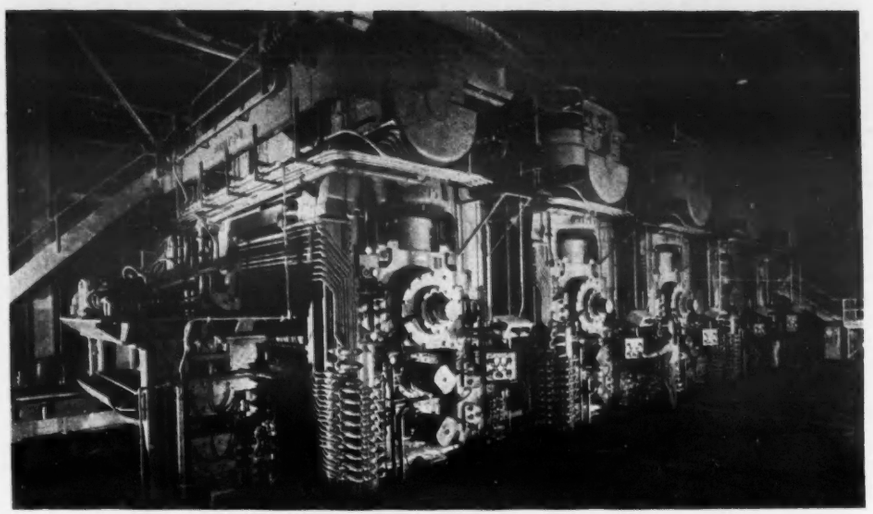


Fig. 7—United 100in five-stand tandem four-high mill with twin rewinding reels and 1250ft per minute output speed

tandem mill. In a single continuous pass, it reduces the slab to a sheet of aluminium about $^1/_{10}$in thick and nearly $\frac{1}{2}$-mile long. It will handle metal up to 90in wide and will produce coils weighing up to 5 tons. Its maximum finishing speed is 1250ft per minute. The minimum gauge of finished sheet is 0·072in ; maximum gauge is about 0·300in.

Each of the five stands is equipped with guides, scratch brushes and other auxiliaries. At the delivery end of the fifth stand is an X-ray thickness gauge as well as side trimming and scrap chopping equipment. The work rolls are 32in maximum diameter ; the backup rolls 54in maximum diameter. The power of the five drive motors totals 24,000 h.p. The control pulpit is similar to those of the other mills. Kaiser Aluminum at present is setting up an automatic control system for this mill, too. It involves a more elaborate system, for the electronic unit must control and synchronise five mills instead of just one. When it is in operation, the operator will simply dial the rolling schedule and the mill will do the rest.

As the sheet emerges from the fifth stand, it is wrapped into a tight coil by either of two rewind reels on the 100in mill coiler. Then a system of coil handling units bands, weighs, up-ends and conveys the coil into the cold rolling bay.

Cold Rolling

Hot rolled sheet off the five-stand tandem mill is of little use to most aluminium sheet users. They require thinner gauges, brighter finishes, different tempers and smaller coils. They may want flat sheets, or circles, or deep drawing blanks, or corrugated sheet, or aluminium foil no thicker than 0·00025in. Producing these useful forms is the job of the plant and equipment in the cold rolling and finishing bays of the Ravenswood Works. Before the hot rolled material can take further fabrication, however, it must be annealed to a workable temper. This is accomplished in a battery of ten coil annealing furnaces built by the Surface Combustion Corporation. Annealed coiled sheet is cold rolled to gauges of 0·006in to 0·175in in the "Blaw-Knox" 72in two-stand tandem sheet mill. This important piece of equipment takes coils weighing up to 5 tons each and measuring 57in outside diameter on the mandrel. The maximum entry gauge is 0·275in; minimum gauge is about 0·025in. The mill can produce coils of sheet as wide as 66in and as narrow as 27in. In reducing hot rolled stock to finished sheet it usually makes reductions exceeding 50 per cent. It is a three-speed mill ; maximum speed is 3300ft per minute, intermediate speed is 2340ft per minute, slow speed is 1200ft per minute.

There also is a "Blaw-Knox" single-stand 72in sheet mill, similar in construction to the two-stand mill. Rounding out the cold rolling facilities at the Ravenswood Works is the "Blaw-Knox" 60in light gauge sheet mill. It can take a 5-ton 57in diameter coil of 0·102in re-roll stock and roll it down to a sheet as thin as 0·0035in at speeds ranging from 2830ft to 1030ft per minute. It has been in operation since January, 1957, processing re-roll stock from the Trentwood Works of Kaiser Aluminum.

From the cold rolling mill, aluminium sheet may go through any number of subsequent operations before being inspected, weighed, wrapped and shipped to the customer. It may be uncoiled and cut into flat sheets on one of three "Wean" flying shear lines. It may be cut into narrow coils on the "Wean" 36in coil slitting line or one of the two "Wean" 60in slitters. It may go through one of the two "Stamco" corrugators, or be given a decorative finish on the "Wean" embossing machine. Customers' orders may require the services of the caustic etch line, or one of the three "Hyde Park" sheet stretchers, or one of the three "Stamco" automatic resquaring lines. Blanking presses are on hand to produce circles or shapes measuring up to 60in by 72in. Special tempers are imparted by annealing ovens and heat-treating furnaces. Only recently installed was a "Sack" 42in two-high bright sheet mill. It will produce one-sided and two-sided bright sheet for use in automobile trim, appliance parts, utensils, flatware, jewellery, nameplates and other products.

Foil Rolling

A substantial share of Ravenswood's sheet output is further processed into foil as wide as 66in and as thin as 0·00025in. Foil has been rolled on two "Blaw-Knox" 60in mills since March, 1957, and on a "Loewy" 72in mill since March, 1958. This latter mill can take reroll stock as wide as 66in and as thick as 0·008in and roll it down to 0·00025in by "doubling." It operates at speeds up to 4000ft per minute, and uses an automatic gauge control with X-ray gauge sensing. The foil capacity will be augmented by a fourth "Loewy" foil mill of 64in width.

The foil processing equipment at Ravenswood includes ten annealing furnaces, two 60in slitting lines, two 60in separating-slitting lines, a 66in separating slitter, and two 32in slitting lines. Substantial amounts of aluminium foil are shipped to the foil processing plant of Kaiser

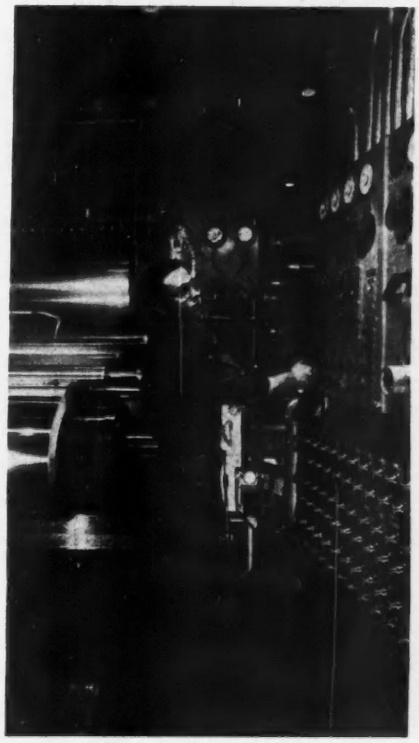


Fig. 8—"Loewy" 72in four-high foil mill with X-ray gauging and automatic gauge control

Aluminum at Belpre, Ohio. At this plant the ultra-thin sheet is processed into cigarette stock, insulation foil, gravure printer stock, converter stock, and gift wrap and fancy paper stock. The plant, which also packages Kaiser Aluminum household foil, made its first shipments in January, 1958.

Plate Rolling

In addition to sheet and foil, the Ravenswood Works also produces aluminium plate. Plate is now rolled by the 168in reversing breakdown mill at the head of the hot line. A 144in reversing cold plate mill is being built for Kaiser by the United Engineering and Foundry Company. Also on order is a heavy plate stretcher, designed primarily to supply stress-relieved plate to the shipbuilding, transport and construction industries. Claimed to be the largest aluminium plate stretcher in the world, it is being built by Hydraulik of Duisburg. It will be capable of exerting a pull of up to 30,000,000 lb on plate having a maximum cross-sectional area of 640 square inches.

Finally, the heavy plate fabrication facility will also require an aluminium plate saw which is now being designed and built by the Loma Machine Manufacturing Company. The saw will be capable of handling plates up to 6in thick, 14ft wide, and 64ft long.

SPERT-III Achieves Criticality

The Special Power Excursion Reactor Test No. 3 (SPERT–III), a versatile research facility developed for studying nuclear reactor safety, recently achieved criticality at the Atomic Energy Commission's National Reactor Testing Station in Idaho Falls, Idaho. SPERT–III was constructed for the Commission by Paul Hardeman, Incorporated, of Los Angeles, California. The Phillips Petroleum Company, which is operating the facility for the Commission, furnished the conceptual design and the Stearns-Roger Manufacturing Company of Denver, Colorado, accomplished the detailed design.

SPERT–III is one of a series of reactors designed and developed by Phillips as part of the Commission's programme to find basic explanations for reactor behaviour under runaway conditions. All operations are conducted remotely since the tests approach reactor destruction. This facility provides the widest practical range of control over three variables—temperature, pressure and coolant flow rate. The plant is expected to contribute significantly to a better understanding of reactor self-limiting and occasional instability characteristics as exhibited in more than 750 excursions in SPERT–I.

The SPERT–I reactor, which began operation in July, 1955, was the first of a series established to investigate potential hazards associated with the broad class of heterogeneous, water-moderated, enriched fuel reactors. The second reactor in the SPERT series, SPERT–II, is still under construction. It will continue the same studies initiated by SPERT–I, but with special emphasis on how various moderators and reflectors, including heavy water, influence reactor behaviour. Tests in SPERT–I, using a simple open-tank system, are generally characterised by sudden power rises that are arrested by the inherent shut-down or self-limiting tendency of the reactor itself. Without any external control rod manipulation, the reactor power reaches a peak in a fraction of a second and drops off to much lower, but generally steady, levels. In some cases, however, instabilities also are observed following the power peaks. Some of these are divergent oscillations that probably could destroy the reactor, despite its self-limiting characteristics, if allowed to continue.

The precise causes of the self-limitation and power instabilities observed in SPERT–I are not known. In an effort to obtain a thorough understanding of these and other phenomena, the Commission has authorised a long-range basic research programme in which the major possible causes will be tested for verification. This programme will require the continued operation of SPERT–I, together with SPERT–II and III, and may entail future construction of additional reactors in the SPERT series. Data derived from the SPERT experiments will have specific application to many military and civilian power reactors currently in use or under construction.

A series of nuclear physics measurements leading to a special programme of reactor hazards studies will be started immediately in SPERT–III. Although SPERT–III is classified as a high-pressure, high-temperature, light water moderated and cooled reactor, its versatility will facilitate the performance of transient tests under various initial conditions of pressure, temperature and coolant flow. Pressures ranging from atmospheric to 2500 lb per square inch, and water temperatures from 68 deg. to 668 deg. Fah. are attainable in the complex facility. Also, the coolant flow rates range from zero to 20,000 gallons per minute, with heat removal capacities up to 60,000kW for a duration of thirty minutes. SPERT–III can be used, therefore, to investigate conditions applicable to many reactor fields, including both pressurised and boiling water power reactors. The facility consists of a reactor vessel, pressurising tank and two primary coolant loops, including pumps, heat exchangers, and and other necessary auxiliary equipment. The reactor and coolant system are designed to be operated from a control centre half a mile away. SPERT–III is fuelled with highly enriched uranium. Positions are provided in the reactor for sixty-eight fuel assemblies, including the fuel sections of the eight control rods. The reactor vessel itself is capable of withstanding shock pressures up to 3500 lb per square inch.

Personal and Business

Appointments

MR. JOHN SIM has been appointed general manager of Westool, Ltd.

MR. J. D. SINCLAIR has been appointed manager of the industrial division of Amplivox, Ltd.

SIR JOHN DEAN has been appointed a director of British Insulated Callender's Cables, Ltd.

MR. S. H. OLIVER has been appointed assistant manager of the group purchasing department of the Wakefield Castrol Group.

MR. A. T. CRAWFORD, M.I.E.E., has been appointed manager, home contracts department, of A. Reyrolle and Co., Ltd.

MR. A. ELMER has been appointed general manager of the industrial division of Rotol, Ltd., in succession to Mr. W. G. Savory, who has resigned.

GEORGE BRAY AND CO., Ltd., announces that Mr. C. J. Wynne-Williams has been appointed general sales manager and Mr. E. Cawood manager of technical sales department.

MR. DAVID H. MCMURTRIE has assumed the duties of public relations officer of Martin, Black and Co. (Wire Ropes), Ltd., and the Speedwell Wire Company, Ltd., Coatbridge, near Glasgow.

THE MINISTRY OF TRANSPORT AND CIVIL AVIATION has announced the appointment of Mr. J. R. Turner to the Coastal Shipping Advisory Committee in succession to Mr. M. Arnet Robinson.

ELECTRO-HYDRAULICS, Ltd., announces that Mr. A. Harold and Mr. R. Edwardes have been appointed directors. Mr. T. C. Wright has been appointed a director of Conveyancer Fork Trucks, Ltd.

THE WHITECROSS COMPANY, Ltd., announces that Mr. K. McKell has succeeded Mr. T. Watters as manager of the wire rope department, and Mr. L. P. Savill has been appointed technical manager.

SIR W. H. BAILEY AND CO., Ltd., announces that Mr. S. Watts has been appointed chief engineer (contracts division), and that Mr. B. Scott-Garrett has joined the company as chief engineer (control division).

THE MINISTRY OF SUPPLY announces that Mr. H. E. Drew has been appointed director of electronics production (air) in succession to Mr. R. E. Sainsbury, who is attending the 1959 course at the Imperial Defence College.

LONDON TRANSPORT announces that Mr. G. S. Bingham, M.I.Mech.E., has been appointed mechanical engineer (works and contracts). Mr. E. P. Lumley, A.M.I.E.E., has been appointed assistant mechanical engineer (works).

CROMPTON PARKINSON, Ltd., has announced that Mr. A. E. Gregg, A.I.E.E., has been appointed general manager of F. and A. Parkinson, Ltd., Guiseley. Mr. J. C. Mansfield has been appointed product manager for Guiseley motors.

GLOVER AND MAIN, Ltd., has announced that, following the retirement of Colonel W. R. Glover, Mr. P. D. M. Aird has been appointed chairman of Glover and Main, Ltd., and the principal associated trading companies, Thomas Glover and Co., Ltd., R. and A. Main, Ltd., and Main Water Heaters, Ltd.

MARCONI INSTRUMENTS, Ltd., announces that Mr. J. E. Taylor, a technical sales engineer of the commercial department, has been seconded to the company's agent in India, Associated Instrument Manufacturers (India), Private, Ltd., where he will assist in the setting up and operating of a calibration centre in Delhi.

THE MINISTRY OF SUPPLY AND CIVIL AVIATION has announced the appointment of Mr. K. W. C. Grand, general manager of the Western Region of British Railways, to be a whole-time member of the British Transport Commission, to fill the vacancy caused by the death of the late Mr. J. W. Watkins. Major-General G. N. Russell, chairman of the Board of Management of British Road Services, has been appointed to be a whole-time member of the Commission in place of Lord Rusholme, who will retire from the Commission on September 30 next.

RHODES, BRYDON AND YOUATT, Ltd., announces that Mr. C. S. Youatt, has relinquished his position as deputy chairman but continues as a director, after forty-three years' service with the company. Mr. A. H. Parkes, a director of the company, and deputy chairman and managing director of Small and Parkes, Ltd., has been appointed deputy chairman. Mr. R. L. Furnival has resigned from the board of directors of Furnival and Co., Ltd. Mr. Harry Aston has been elected to the board and will take up his appointment as chief engineer to both companies on March 2.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces the following appointments :—Mr. G. R. Higgs, M.I.E.E., chief engineer, traction projects department ; this appointment will enable Mr. F. Whyman, who relinquishes the position, to devote his full time to his duties as chief engineer, traction division. Mr. J. Beasley, A.M.I.E.E., has been appointed assistant chief engineer, traction control department, in succession to Mr. A. D. Ferguson, who has been appointed consulting engineer, traction control department. Mr. J. L. Russell, A.M.I.E.E., has been appointed chief engineer, railway signals department ; responsibility for this department has been relinquished by Mr. W. T. Gray, chief engineer, traction control department. Mr. J. F. Hancock has been appointed assistant superintendent, maintenance department.

Business Announcements

HILGER AND WATTS, Ltd., has announced the formation of an affiliated U.S.A. company, Hilger and Watts, Inc., in association with Engis Equipment Company, of Chicago.

THE ULTRASONOSCOPE COMPANY (LONDON), Ltd., Sudbourne Road, Brixton Hill, London, S.W.2, announces that it has instituted a free technical service to advise on all aspects of ultrasonic flaw detection and inspection.

MR. L. K. EVERITT and MR. W. J. MCBRIDE, directors of Edgar Allen and Co., Ltd., are visiting South Africa and Rhodesia. Mr. McBride will later attend the opening in Iran, by the Shah of Persia, of the new cement factory, equipment for which has largely been supplied by this company.

Contracts

THE GENERAL ELECTRIC COMPANY, Ltd., has received an order from the London Transport Executive for traction motors worth well over £1,250,000. This comprises 1400 motors for Central Line stock, an option for which was placed when motors for the Piccadilly and Metropolitan Lines were ordered from the company last year. Now that the option has been taken up, the combined value, totalling well over £2,500,000, constitutes the largest order for traction motors ever placed by any railway in this country, covering a total of 2656 motors. The continuous rating of the Central Line motors will be 60 h.p. at 66 per cent field.

Miscellanea

SHAPED ALUMINIUM INGOT.—Aluminium Union, Ltd., announces that it has introduced a new pattern inter-locking 50 lb ingot which is safer, easier and quicker to handle during transport and by users. The ingot shape enables full advantage to be taken of mechanical handling equipment and ensures that in strapped bundles the ingots are locked together in vertical, lateral and lengthwise directions.

CONCAVE MAGNETIC CONVEYOR ROLLS.—Concave magnetic rolls are now being made by Rapid Magnetic Machines, Ltd., Lombard Street, Birmingham, 12. These rolls are designed to provide an economic means for such work as conveying lengths of freshly galvanised pipes from the bath to a rack. In such an application the operator simply hooks the pipe from the bath by tongs and places one end against the underside of the magnetic roll, which then automatically transfers the pipe, in a suspended position, from the bath to a rack or a conveyor.

HARDFACING USING INDUCTION HEATING.—A system of hardfacing metals with "Stellite" using automatic induction heating has been developed jointly by Deloro Stellite, Ltd., Shirley, Solihull, Warwickshire, and Radio Heaters, Ltd., Wokingham, Berks. This system is stated to eliminate need for welding skill and promote economic use of the hard alloy when facing such things as valve seatings, seat rings, discs, &c. In it "Stellite" powder and a flux are placed in a recess machined in the blank and fused to the parent metal on a "Radyne" induction equipment.

BULK PRODUCTION OF PURE SILICON IN BRITAIN.—A large-scale development plant for the manufacture of high-purity silicon suitable for semi-conductors has been brought into operation by Imperial Chemical Industries, Ltd., at its general chemicals division, Merseyside. By the middle of this year its capacity is expected to exceed 4000 lb per annum ; plans for larger production are stated to be well advanced. Silicon can be supplied by I.C.I. in either of two forms. Lump-silicon, p-type of resistivity greater than 200 ohm cm is now available in quantity. Silicon in rod form for zone refining, deposited direct from the vapour and of exceptionally low boron content is being produced in limited quantities in lengths of 24in and diameters up to 1in. If the demand is sufficient the company is prepared to supply silicon rod already zone refined into monocrystalline rods. The company expects to be able to meet Britain's demand (hitherto America and France have been the main suppliers) and, later, to enter the export market.

BENDING ALUMINIUM.—The Aluminium Development Association, 33, Grosvenor Street, London, W.1, has published Information Bulletin 24, "Bending Aluminium" price 2s. This Bulletin is directed to production engineers, designers, works managers, foremen and operators and its scope includes the more usual bending operations and excludes the unusual. The publication opens with the classification of aluminium alloys and the choice of materials for bending or flanging and then proceeds to deal with bending operations, tools, pressures, &c., the operations being referred to sheet, strip, plate sections and tubes.

MACHINE TOOL DEMONSTRATION.—A new range of horizontal, vertical and universal milling machines, which has been developed by F. Werner, Berlin, will be introduced in this country at demonstrations staged by the Rockwell Machine Tool Company, Ltd., at its London showrooms from March 9 to March 20 and its Birmingham showrooms from April 7 till April 17 next. In addition to the new milling machines there will also be demonstrated some "Matrix" measuring equipments and machine tools ; Thiel tool room machines ; Jung internal grinders, and other machines handled by the firm in this country.

FAST PATROL BOAT TRIALS.—We are informed that, during preliminary trials, the fast patrol boat H.M.S. "Brave Borderer" exceeded a speed of 50 knots. The boat was built by Vosper, Ltd., and is propelled by three Bristol "Marine Proteus" gas turbines driving through a primary reduction gear and a hydraulically operated reverse/reduction gear manufactured by W. H. Allen, Sons and Co., Ltd. The engine, which has a half-hour rating of 3500 h.p. and a continuous rating of 2800 h.p. for a weight of 2900 lb, was illustrated in our issue of August 30, 1957, and general particulars, together with a drawing of the installation, appeared in THE ENGINEER of January 24, 1958.

FUEL CONSUMPTION MEASUREMENT.—An electronic installation for the measurement of fuel consumption with high accuracy has been installed by Leyland Motors, Ltd., to allow small changes in efficiency to be readily detected. The installation, developed by Farnell Instruments, Ltd., includes a transparent burette through which the engine is supplied with fuel. To make a test, the supply to the burette is cut off : when the fuel level reaches the upper mark on the burette, a photo-electric cell energises a time counter and an engine revolution counter, which are stopped by a second photo-cell at the lower mark ; thus, the result does not depend on a measurement of engine speed. At the end of the measurement the supply of fuel to the burette is automatically restored. Tests over a period of less than one minute are accurate within 1 per cent, we are advised.

TABULAR SUMMARY OF CIVIL ENGINEERING CONTRACTS.—The 1958 edition of the *Tabular Summary of Civil Engineering Contracts* was published with THE ENGINEER of December 26 last. It has been pointed out to us that there are errors in the entries for the C.E.G.B.'s nuclear power stations, on page 28. The civil engineering contractor for Bradwell is Sir Robert McAlpine and Sons, Ltd., the other two contracting firms listed against Bradwell are entered in error. The design and construction of the station generally is in the hands of the Nuclear Power Plant Company, Ltd., a consortium of which the contractor named above is a member. Furthermore, at Berkeley the civil engineering contractors are Balfour Beatty and Co., Ltd., and John Laing and Son, Ltd., and at Hinkley Point the civil engineering contractor is Taylor Woodrow Construction, Ltd.; The corresponding names given in the "Main Contractors" column on page 28 of the *Tabular Summary* are in error. At Berkeley and Hinkley Point respectively the consortia are the A.E.I.-John Thompson Nuclear Energy Company, and English Electric-Babcock and Wilcox-Taylor Woodrow Atomic Power Group. Two further entries, relating to Hinkley Point and Berkeley are given on page 26 of the *Tabular Summary*. A notable omission from the *Tabular Summary* in the "Roads" section is the contract for the foundation work of the Forth Suspension Bridge, for which the consultant is Messrs. Mott, Hay and Anderson, and the contractor is John Howard and Co., Ltd.; the value of the contract is approximately £2,500,000.

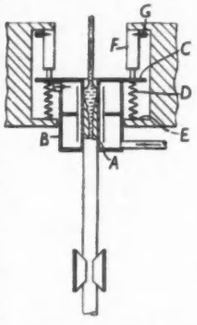
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings, unless otherwise stated. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

METALLURGY

806,803. May 25, 1954.—CONTINUOUS CASTING OF METAL, The British Iron and Steel Research Association, 11, Park Lane, London, W.1.

This invention relates in particular to the continuous casting of metal in which the liquid metal is poured into an open mould and is withdrawn as a partly solidified billet. An object of the invention is to enable the billet to be released from the mould wall on sticking, or to minimise the opportunity of sticking, while reducing the chances of rupturing of the billet skin. Referring to the drawing, which represents a method of automatically controlling mould movement, the continuous casting mould *A* is provided with a cooling jacket *B*. The mould is mounted on a top plate *C* extending beyond the jacket and is supported for vertical movement by three compression springs *D*. These springs are mounted from the surface *E* of an annular recess of a support member. Aligned with springs and between the top of the recess and the plate *C* are three pneumatic rams *F*. These rams provide a sudden impact on the application of compressed air to the inlet pipes *G*. Provided that no sticking of the billet occurs, the mould remains substantially stationary, the billet being withdrawn continuously from it. When sticking occurs, the tension applied through the billet will cause the mould to move down against the action of springs. When the tension reaches a predetermined value, compression of the springs will allow the plate *C* to engage a switch which controls a solenoid operated pilot valve for the supply of compressed air to the rams *F*. As soon as the switch is closed, the compressed air is supplied to the rams so that they apply an impulse to the mould to cause it to move down for a short distance at a speed greater than the withdrawal speed of the billet. This impulse releases the billet from the mould and as it is in a direction causing a compressive force to be applied to the billet, release is effected without rupturing the billet skin. The position of the controlling switch, the strength of the springs and other factors are determined by the size of the billet and the casting rate, so as to prevent rupture in the billet. An alternative form of construction is also given in the specification.—*December* 31, 1958.

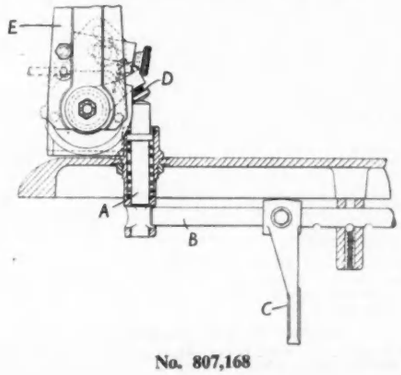


No. 806,803

MOTOR VEHICLES

807,168. May 15, 1956.—CONTROL MECHANISM FOR MOTOR VEHICLES, Morris Motors, Ltd., Tractor and Transmissions Branch, of Ward End, Birmingham, 8. (*Inventor: Leslie Alfred Watton.*)

The control mechanism is designed to prevent the engagement of top gear when a vehicle engine throttle valve is in a setting at which the engine speed exceeds that corresponding to the predetermined ground speed. The drawing shows a side elevation of the control mechanism applied to the gearbox of an agricultural tractor. In the gearbox, a spring-loaded plunger *A* in a sleeve fitted to the top cover is so arranged that when depressed it lies across the path of the top-gear selector shaft *B* and positively prevents engagement of top gear by the usual shifter *C*. When the gearbox is in neutral, as shown, the forward end of the selector shaft is just clear of the plunger. The top of the plunger protruding from the upper end sleeve makes contact with the head of an adjustable screw abutment *D* carried by an arm fixed to the spindle of the control lever *E* of the engine throttle valve linkage. The control mechanism is adjusted initially so that, with top gear engaged and the plunger depressed manually into contact with the top gear selector shaft (which enters a guidance hole in the sleeve), the adjustable abutment engages the top of the plunger when the throttle valve setting is such as to give the engine speed corresponding to the required limitation of the top-gear speed of the vehicle. When the throttle control lever is in the fully-open setting, the plunger concomitantly has been depressed to make it impossible to engage top gear. Also, when the vehicle is in top gear it is impossible for the throttle control lever to be moved into the fully-open position because the selector shaft then prevents depression of the plunger.—*January* 7, 1959.

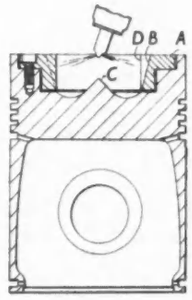


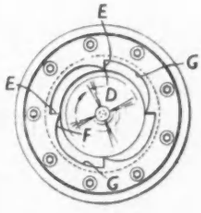
No. 807,168

INTERNAL COMBUSTION ENGINES

807,712. January 27, 1956.—INTERNAL COMBUSTION ENGINE OF THE LIQUID FUEL INJECTION TYPE, Ricardo and Co., Engineers (1927), Ltd., 21, Suffolk Street, Pall Mall, London, S.W.1. (*Inventor: Brian Wyatt Millington.*)

The drawing shows a diagrammatic sectional elevation of a piston for an internal combustion engine embodying the invention. The piston has a combustion chamber recess formed partly in its crown and partly in an annular insert *A* secured in a recess in the crown. The combustion chamber recess comprises a frusto conical side wall *B* with its larger end uppermost and a bottom wall having a central conical portion *C* gradually flattening out and curving upwards to merge with the side wall. A fuel injection nozzle directs a number of jets in a substantially radial direction with a slight component downwards parallel to the axis. As shown in the lower view the circumferential wall *B* is composed of four pairs of surfaces, each pair meeting at an edge *D* extending generally parallel to the axis and comprising a surface *E* which extends in a substantially radial direction and a surface *F*, which extends in a predominently circumferential direction. The surface *F* includes a portion *G* which is coaxial with the axis of the combustion chamber recess. As indicated by the arrow the air is caused to rotate in a clockwise direction so as to approach each edge *D* along the adjacent circumferential surface *F*, *G*. The precise form of the circumferential walls of the recess may vary widely. In the particular form shown each edge *D* may be regarded as the edge of a ratchet tooth projecting inwards from a surfac eof revolution. If desired, however, each circumferential surface adjacent the re-entrant edge may be co-axial with the combustion chamber recess and may merge with a surface leading to the outer edge of the radial surface along a line which is an outward spiral or even a tangent. In this event the re-entrant edges may be regarded as being formed by recesses of ratchet tooth shape formed in a surface of revolution. The inclination of each re-entrant edge *D* to the axis may also vary. It is believed that the improvement in combustion efficiency obtained with the invention, as compared with combustion chamber recesses having circumferential walls of approximately circular form, is due at least partially to the fact that liquid fuel which may tend to accumulate on the circumferential wall and be swept over its surface by the rotating air charge is caused, when it reaches one of the re-entrant edges, to be swept off into the body of the air charge rather than flowing along the more or less radial surface. The efficiency of combustion may, however, also be attributable at least partially to the additional turbulence or eddies, which the re-entrant edge tends to superimpose upon the general bodily rotation of the air charge in the combustion chamber recess about the main axis of rotation.—*January* 21, 1959.

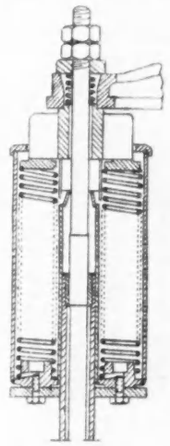




No. 807,712

807,771. May 25, 1956.—INTERNAL COMBUSTION ENGINE VALVE GEARS, Aktiebolaget Gotaverken, Gothenburg, Sweden.

According to the invention there is provided an arrangement for an engine valve gear by which the movement in one direction is obtained by the action of a number of spring units arranged parallel to each other for co-operation with a valve stem, pull or push rod. The springs are arranged round the valve stem as shown in the drawing and the spring units are separately encased in tubular guides which are open at the top and closed at the bottom and filled with oil to a substantial part of the height of the springs.—*January* 21, 1959.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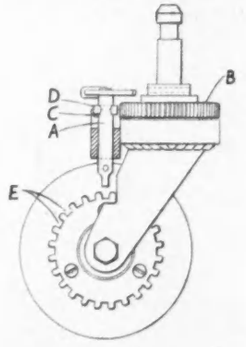
CASTORS

807,657. July 27, 1956.—CASTORS, Flexello Castors and Wheels, Ltd., Bath Road, Trading Estate, Slough, Buckingham, and Stanley Edwin Wapshott, of the company's address.

This invention relates particularly to heavy castors incorporating an improved combined swivel and wheel lock. In the construction shown the locking member takes the form of a vertically slidable pin *A* having at its upper end a serrated head for engaging the serrations on a fixed bearing race cover *B* concentric with the swivelling axis of the castor. The top of the pin also carries a foot-operated pedal, which, when depressed, urges the head into engagement with the serrations on the bearing cover. The locking pin, once the ball or plunger *C* has been overridden by a guide pin *D* will move into its locking position under gravity. The locking pin, at its lower end, is shaped to enter any one of a series of closely spaced notches in an annular locking plate *E* secured to one side of the castor wheel at the same time as its head engages the serrations on the bearing cover. Alternative arrangements of the device are also given in the specification.—*January* 21, 1959.



No. 807,657

Catalogues and Brochures

RENOLD CHAINS, Ltd., Manchester.—Folder giving details of "The Coventry" slat band chains and wheels.

KODAK, Ltd., Victoria Road, Ruislip, Middlesex.—Folder illustrating the "Verifax Signet" document copying machine.

KODAK, Ltd., Victoria Road, Ruislip, Middlesex.—Leaflet dealing with the technical close-up camera kit manufactured by this company.

FERRANTI, Ltd., Hollinwood, Lancs.—Folders giving details of the Ferranti transistorised tape reader TR5, and the 1009 magnetic drum.

LAURENCE SCOTT AND ELECTROMOTORS, Ltd., Gothic Works, Norwich.—Leaflet illustrating and describing the N-S variable-speed a.c. motor.

ROCKWELD, Ltd., Commerce Way, Croydon, Surrey.—Leaflet illustrating and describing the "Autopak" automatic arc welding equipment.

TODD BROS. (ST. HELENS AND WIDNES), Ltd., St. Helens, Lancs.—Illustrated leaflet giving details of the firm's new structural steelwork department.

NEGRETTI AND ZAMBRA, Ltd., 122, Regent Street, London, W.1.—Brochure dealing with the products of this company, printed entirely in Czechoslovakian.

STANDARD TELEPHONES AND CABLES, Ltd., Rectifier Division, Edinburgh Way, Harlow, Essex.—Leaflets describing silicon high-power rectifiers, series RS8, silicon rectifier stacks, series RS3 and RS5, silicon junction power rectifiers, series RS5.

W. F. STANLEY AND CO., Ltd., New Eltham, London, S.E.9.—Catalogue describing and illustrating the Stanley range of surveying instruments and equipment, and also the complete range of products manufactured by the company and its associates.

STANLEY HOWARD, Ltd., 73, Devon Street, Birmingham.—Leaflets dealing with the "Skinner No. 3" differential lead screw unit head designed for drilling, counter boring, spot facing, reaming and similar operations, and the "Uni-Tap" tapping unit, for which this firm is the sole selling agent.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Sat., Feb. 21.—OXFORD AND DISTRICT BRANCH: St. John's Hall, Marston Street, Oxford, "Electric Floor Warming." 7 p.m. ★ SOUTH EAST LONDON BRANCH: Visit to the National Physical Laboratory, Teddington, 2 p.m.

Tues., Feb. 24.—LONDON NATIONAL LECTURE: Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Hospital Electrical Installations and Apparatus," J. W. J. Leslie, 6.30 p.m.

Thurs., Feb. 26.—BRIGHTON, HOVE AND DISTRICT BRANCH: New Imperial Hotel, First Avenue, Hove, "Modern Electric Motor Specification," 7.30 p.m. ★ SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, "A.C. Motor Control Gear," W. G. Stoner, 8 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Thurs. and Fri., Feb. 26 *and* 27.—Town Hall, Leamington Spa, 1959 Midland Management Conference on "Management in a Competitive World."

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Feb. 20.—SCOTTISH SECTION: Department of Natural Philosophy, The University, Drummond Street, Edinburgh, "True Motion Radar," J. H. Beattie, 7 p.m. ★ MERSEYSIDE SECTION: University Club, Liverpool, "Electronic Welding Controls," C. R. Bates, 7 p.m.

Wed., Feb. 25.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Patents and the Radio Engineer," E. D. Swann, 6.30 p.m.

Fri., Feb. 27.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Micro-Miniaturization," G. W. A. Dummer, 7 p.m.

CHEMICAL SOCIETY

Thurs., Feb. 26.—Lecture Theatre, Royal Institution, Albemarle Street, London, W.1, "The Origin of the Elements," F. Hoyle, 7.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Feb. 25.—WESTERN REGION: Conference Room, Old Head Office (adjacent to Port Talbot Station), Steel Company of Wales, Ltd., Port Talbot, "Reactor Engineering," J. W. Ashley, 11 a.m.; "The Refining of Crude Oil and the Use of the Products," R. R. B. Cox, 2.15 p.m.

ILLUMINATING ENGINEERING SOCIETY

Fri., Feb. 27.—BIRMINGHAM CENTRE: Regent House, St. Philip's Place, Colmore Row, Birmingham, Annual General Meeting; Address by the President, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Feb. 25.—LONDON BRANCH: Constitutional Club, Northumberland Avenue, London, W.C.2, "Some Achievements of the Institute's Technical Council," A. B. Everest, 7.30 p.m.

INSTITUTE OF FUEL

Tues., Feb. 24.—SCOTTISH SECTION: Royal College of Science and Technology, Glasgow, "Present Trends in Research on Coking Properties of Coal," Helen McKellar, 7 p.m.

Wed., Feb. 25.—LONDON SECTION: Institution of Civil Engineers, Great George Street, London, S.W.1, "Investigations in Germany Concerning Atmospheric Pollution," H. Lent, 5.30 p.m.

Thurs., Feb. 26.—EAST MIDLAND SECTION: Gas Showrooms Lecture Theatre, Nottingham, "Recent Developments in the Heating of Domestic Premises," S. A. Burke, 6.15 p.m. ★ MIDLAND SECTION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Steam Coating," R. Nichol, 6.30 p.m.

INSTITUTE OF MARINE ENGINEERS

To-day, Feb. 20.—SOUTH WALES SECTION: South Wales Institute, of Engineers, Park Place, Cardiff, "Nuclear Steam Propulsion for Merchant Ships," W. R. Wootton, 7 p.m.

Mon., Feb. 23.—WEST OF ENGLAND SECTION: Grand Hotel, Bristol, Films, "How a Thermal Reactor Works," "Construction of Calder Hall," and the Annual General Meeting, 7.30 p.m.

Tues., Feb. 24.—Memorial Building, 76, Mark Lane, London, E.C.3, Joint Meeting with the Institution of Naval Architects, "Fishing Vessel Development," A. Hunter and G. C. Eddie, 5.30 p.m. ★ MERSEYSIDE AND NORTH WESTERN SECTION: Technical College, Bolton, "Steam Reciprocating Engines," G. Yellowley, 3.15 p.m.

Thurs., Feb. 26.—NORTH EAST COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "Auxiliaries," P. Scorer, 4 p.m.

INSTITUTE OF NAVIGATION

To-day, Feb. 20.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Meteorological Briefing Information," D. McNaughton, 5.15 p.m.

INSTITUTE OF PETROLEUM

Wed., Feb. 25.—LONDON BRANCH: 61, New Cavendish Street, London, W.1, Address by the President, 6 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Feb. 24.—NORTH WESTERN BRANCH: Blossoms Hotel, Chester, "Meat Extract Production in a Whaling Factory Ship," D. King, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 24.—Great George Street, Westminster, London, S.W.1, "The Design and Construction of the Avon Dam," J. M. Linton Bogle, R. M. Ross and Thomas McMillan, 5.30 p.m.

Wed., Feb. 25.—NORTH WESTERN ASSOCIATION: 9, The Temple, 24, Dale Street, Liverpool, Joint Meeting with the Liverpool Engineering Society, "Organizational Problems Associated with the Construction of Large Nuclear Power Stations," J. H. W. Turner, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Feb. 20.—RADIO AND MEASUREMENT SECTIONS: Savoy Place, London, W.C.2, "The Measurement of Errors in Data Transmission for the Design of Detecting and Correcting Equipment," V. J. Terry and E. D. G. Wright, 5.30 p.m. ★ SOUTHERN CENTRE: S.E.B. Showrooms, Newport, Isle of Wight, "Installation of a B.B.C. Television Transmission Station," E. P. Metcalf, 6.30 p.m.

Mon., Feb. 23.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "A Simple Investigation of the Cross-Modulation Distortion arising from the Pulling Effect in a Frequency-Modulated Klystron," D. Gjessing; "Theory and Behaviour of Helix Structures for a High Power Pulsed Travelling-Wave Tube," G. W. Buckley; "A Multi-Cavity Klystron with Double-Tuned Output Circuit," H. J. Curnow and L. E. S. Mathias, and "A Method for the Measurement of Very-High Q-Factors of Electromagnetic Resonators," F. H. James, 5.30 p.m. ★ NORTH-EASTERN CENTRE: Neville Hall, Westgate Road, Newcastle upon Tyne, "Development of High-Voltage Air-Break Circuit-Breakers with Insulated-Steel Plate Arc Chutes," F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton, 6.15 p.m. ★ NORTH-WESTERN SUPPLY GROUP: Engineers' Club, 17, Albert Square, Manchester, "Operational Experience at Calder Hall," K. L. Stretch, 6.15 p.m. ★ SOUTH MIDLAND RADIO AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, "Computing Principles and Applications," A. St. Johnston, 6 p.m. ★ WESTERN UTILIZATION GROUP: Electricity House, Colston Avenue, Bristol, 1, "The Use of Steel-Tank Mercury-Arc Inverters for Generating Medium Frequencies for Induction Heating," D. L. Smart, and J. L. Weaver, 6 p.m.

Tues., Feb. 24.—HENLOW DISTRICT MEETING: R.A.F. Technical College, Henlow, Beds, "The Tracking of the Russian Earth Satellite," D. L. Cooper-Jones, 7.30 p.m. ★ NORTH-WESTERN CENTRE: Free Trade Hall, Manchester, Faraday Lecture on "Automation," H. A. Thomas, 7.30 p.m.

Wed., Feb. 25.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Development of High-Voltage Air-Break Circuit Breakers with Insulated-Steel-Plate Arc Chutes," F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton, 5.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "The Generation of Electricity in the London Area," H. V. Pugh, 7 p.m. ★ RUGBY SUB-CENTRE: College of Technology and Arts, Rugby, "Storage and Manipulation of Information in the Brain," R. L. Beurle, 6.30 p.m.

Thurs., Feb. 26.—MERSEY AND NORTH WALES CENTRE: Philharmonic Hall, Liverpool, Faraday Lecture on "Automation," H. A. Thomas, 6.45 p.m. ★ NORTH MIDLAND CENTRE: Yorkshire Electricity Board Offices, Ferensway, Hull, "Recent Developments in Medium-Voltage High-Breaking Capacity Fuse Links," R. H. Dean, 6.30 p.m.

Fri., Feb. 27.—SOUTHERN CENTRE: South Dorset Technical College, Weymouth, "Survey of Recent Developments in Marine Radar," A. L. P. Milwright, 6.30 p.m.

Sat., Feb. 28.—LONDON GRADUATE AND STUDENT SECTION: Visit to Tower Bridge, London, E.1, 3 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Feb. 25.—YORKSHIRE BRANCH: Midland Hotel, Bradford, "An Outline of Heating and Ventilating Design," C. F. Hart, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 24.—39, Elmbank Crescent, Glasgow, "The Stork Marine Diesel Engine—Construction, Experience, Development," Ir. A. Hootsen and E. A. van der Molen, 6.30 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Feb. 25.—British Lighting Council, Brettenham House, Lancaster Place, London, W.C.2, "Factory and Workshop Lighting," J. F. Roper, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 20.—ORDINARY MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Experimental Study of Some Variables of the Tube Expanding Process," L. E. Culver and Hugh Ford, 6 p.m. ★ MIDLAND GRADUATES' SECTION: Visit to Tubes, Ltd., Rocky Lane, Aston, Birmingham, 7 p.m.

Sat., Feb. 21.—EASTERN GRADUATES' SECTION: Visit to *News of the World*, 7 p.m.

Mon., Feb. 23.—N.E. GRADUATES' SECTION: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, "Astronomy," F. W. James, 6.30 p.m.

Tues., Feb. 24.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Safety Features in Vehicle Design," 6 p.m. ★ EASTERN BRANCH: Good Companions Hotel, Slough, "Artificial Satellites," E. M. Dowlen, 7.30 p.m. ★ BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Years of Development," R. A. Wilson-Jones, 6.30 p.m. ★ EASTERN GRADUATES' SECTION: Visit to Cobbold and Co., Brewers, Cliff Brewery, Ipswich, 7.30 p.m.

Wed., Feb. 25.—APPLIED MECHANICS' GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "The Significance of Thermal Stresses in Design," 6 p.m. ★ E. MIDLANDS BRANCH: College of Technology, Chesterfield, "Development and Research in Industry," H. G. Edmunds, 7.30 p.m. ★ NORTHERN IRELAND BRANCH: Central Hall, College of Technology, Belfast, "Some Experiments with Internal Combustion Engines," R. C. Cross, 7.30 p.m. ★ YORKSHIRE BRANCH: The University, St. George's Square, Sheffield, "Mechanical Marshalling of Railway Wagons in Works Sidings," G. W. Grossmith, 6.30 p.m. ★ WESTERN GRADUATES' SECTION: All-day Visit to Jaguar Cars, Ltd., Coventry.

Thurs., Feb. 26.—WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Fatigue Testing of Vehicle Components," T. C. F. Stott, 6.45 p.m. ★ EASTERN GRADUATES' SECTION: College of Technology, Northampton, Film Show, 7.30 p.m. ★ E. MIDLANDS GRADUATES' SECTION: Gas Showrooms, Church Street, Peterborough, Film Show, 7.15 p.m. ★ WESTERN GRADUATES' SECTION: The College, Swindon, "Some Aspects of Management Consultancy," D. M. Jack, 7.30 p.m.

Fri., Feb. 27.—INFORMAL DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "Choice of Gas Temperature and Steam and Pressure Conditions in Nuclear Power Stations," 6 p.m. ★ LONDON GRADUATES' SECTION: Visit to the Ford Motor Company's new foundry at Dagenham, 2 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Tues., Feb. 24.—Memorial Building, 76, Mark Lane, London E.C.3, Joint Meeting with the Institute of Marine Engineers, "Fishing Vessel Development," A. Hunter and G. C. Eddie, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Feb. 20.—SOUTH WESTERN REGION: Technical College, Brunswick Road, Gloucester, "Fine Measurements," J. C. Evans, 7.30 p.m.

Mon., Feb. 23.—NORTH WESTERN REGION: Reynold's Hall, Manchester College of Science and Technology, Sackville Street, Manchester, "Handling and Packing for Export," D. G. S. Miller, 7.15 p.m.

Wed., Feb. 25.—SOUTH WESTERN REGION: Town Hall, Weston-super-Mare, "Metallic Materials Development," S. G. E. Nash, 7.30 p.m.

Thurs., Feb. 26.—MIDLANDS REGION: College of Further Education, Redditch, Worcs. "Fibreglass Development and Application," G. C. Watson, 7.30 p.m. ★ NORTH MIDLANDS REGION: Ruston Club, Lincoln, "Motor Car Body Industry," J. H. Stephens, 7.30 p.m. ★ ROCHESTER AND DISTRICT GRADUATE SECTION: Sun Hotel, Chatham High Street, Chatham, "New Techniques in Non-Destructive Testing," W. G. Cook, 7.30 p.m.

Fri., Feb. 27.—NORTH MIDLANDS REGION: Louis Room, St. James's Restaurant, St. James's Street, Derby, "Automobile Testing and Development," H. A. Dean, 7 p.m. ★ WALES REGION: South Wales Institute of Engineers, Park Place, Cardiff, "Compressed Air and Some of its Practical Applications," W. J. Ford, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 23.—MANCHESTER SECTION: Grand Hotel, Manchester, "Developments in the Technology of the Direct Moulded Footwear Process," C. E. Webb, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 20.—SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, Glasgow, "Modern Trends in the Design of Steel Bridges and Structures," W. R. Cox, 7 p.m.

Thurs., Feb. 26.—11, Upper Belgrave Street, London, S.W.1, "Extensions to Constructional Shop: 170ft and other Long Spans," F. R. Bullen, 6 p.m.

Fri., Feb. 27.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Birmingham, "Some Structural Problems Particular to Aircraft Design," A. J. Troughton, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 20.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Selection and Use of Arc Welding Processes," E. Flintham, 7 p.m.

Fri., Feb. 27.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Computers and Materials Handling," W. J. Kease and A. C. Quarterman, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 27.—Engineers' Club, Albert Square, Manchester, 2, "Electrical Models and Analogues," E. Bradshaw, 6.45 p.m.

MANCHESTER STATISTICAL SOCIETY

Fri., Feb. 27.—Portico Library, 57, Mosley Street, Manchester, "Applications of Linear Programming Techniques to Problems of Production and Distribution," A. Baines, 6 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 27.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "Some Engineering Developments in the Nuclear Power Field," A. T. Bowden, 6.15 p.m.

PLASTICS INSTITUTE

To-day, Feb. 20.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Recent Developments in the Applications of Epoxy Resins," P. A. Dunn, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Feb. 26.—WEST OF ENGLAND BRANCH: New School of Engineering, The University, Bristol, "A Survey of Recent Developments in Reinforced Concrete," A. W. Hill, 6 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., Feb. 26.—LEICESTER GROUP: Room 104, College of Technology, The Newarke, Leicester, "Statistical Tests of the Accuracy of Weighing," D. H. Ward, 7 p.m. ★ SHEFFIELD GROUP: Cavendish Room, Grand Hotel, Sheffield, "The Analysis of Replicated Experiments on an Electronic Computer," M. J. R. Healy, 7 p.m.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Wed., Feb. 25.—The University Building, St. George's Square, Sheffield, "The Mechanical Marshalling of Railway Wagons in Works Sidings," G. W. Grossmith, 6.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Feb. 24.—CONTROL SECTION: Manson House, Portland Place, London, W.1, Symposium on "Automatic Weight Control in Industry," 6 p.m.

Wed., Feb. 25.—CHESTER SECTION: Grosvenor Museum, Grosvenor Street, Chester, "Automatic Boiler Control," J. E. O'Breen, 7 p.m.

Thurs., Feb. 26.—GRANGEMOUTH SECTION: Leapark Hotel, Grangemouth, "Design Characteristics of Control Valves," A. M. Reid, 7 p.m.

Fri., Feb. 27.—SCOTTISH SECTION: Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Data Handling in the Process Industries," A. Parsons, 7.15 p.m.

TELEVISION SOCIETY

Fri., Feb. 27.—Cinematograph Exhibitors Association, 164, Shaftesbury Avenue, London, W.C.2, Film, "The Wide Wide World," 7 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Feb. 25.—"Hope House," 45, Great Peter Street, Westminster, London, S.W.1, Films, 7 p.m.

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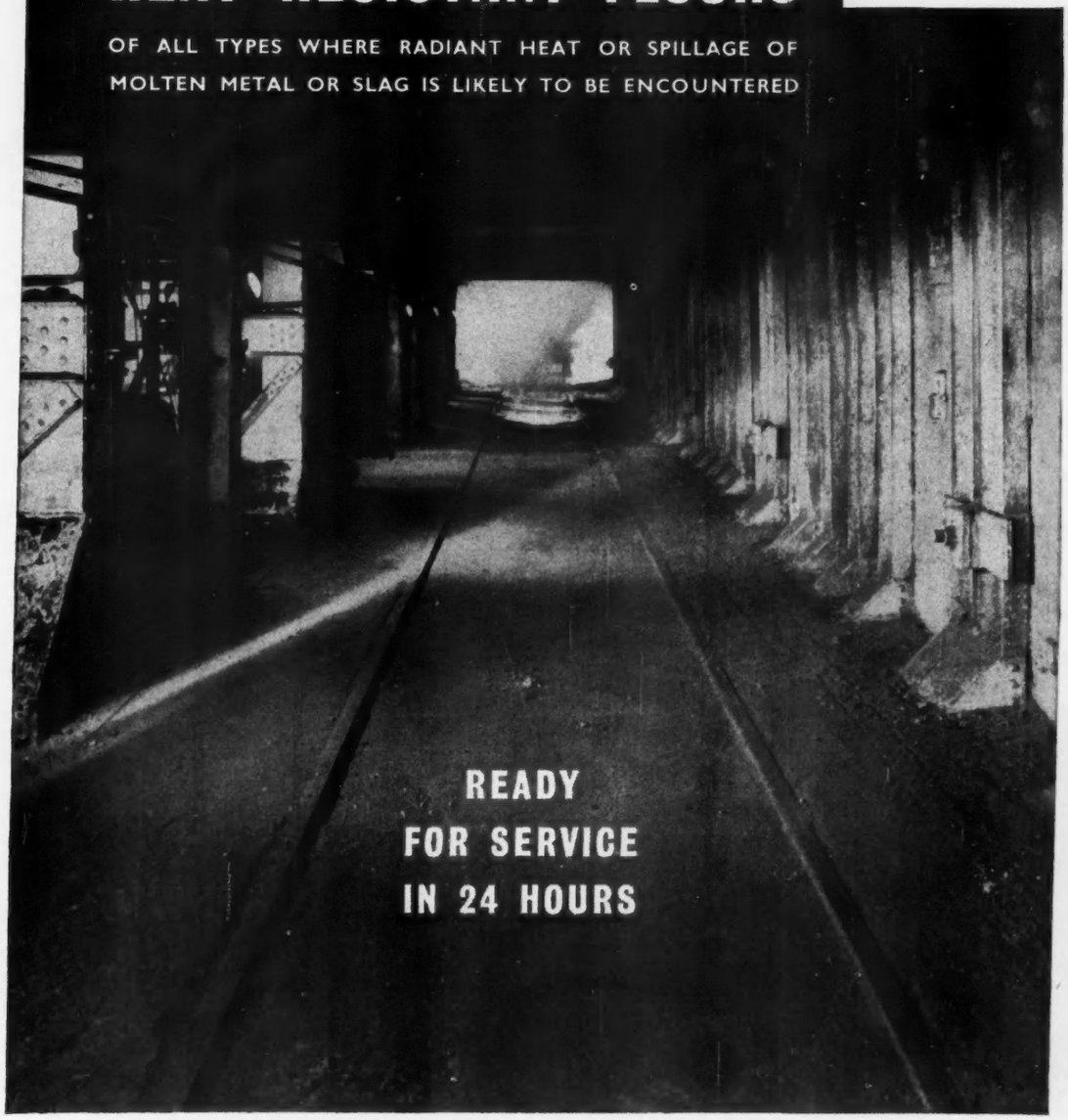

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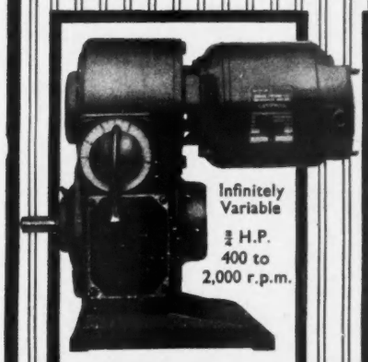

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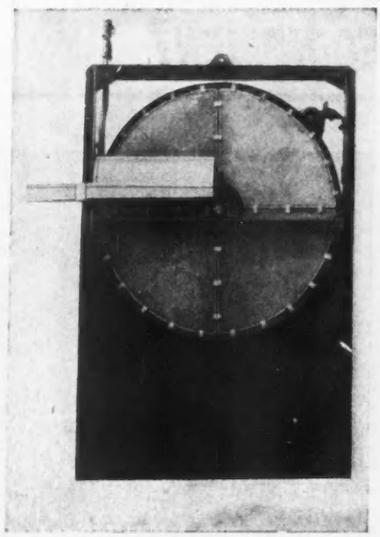

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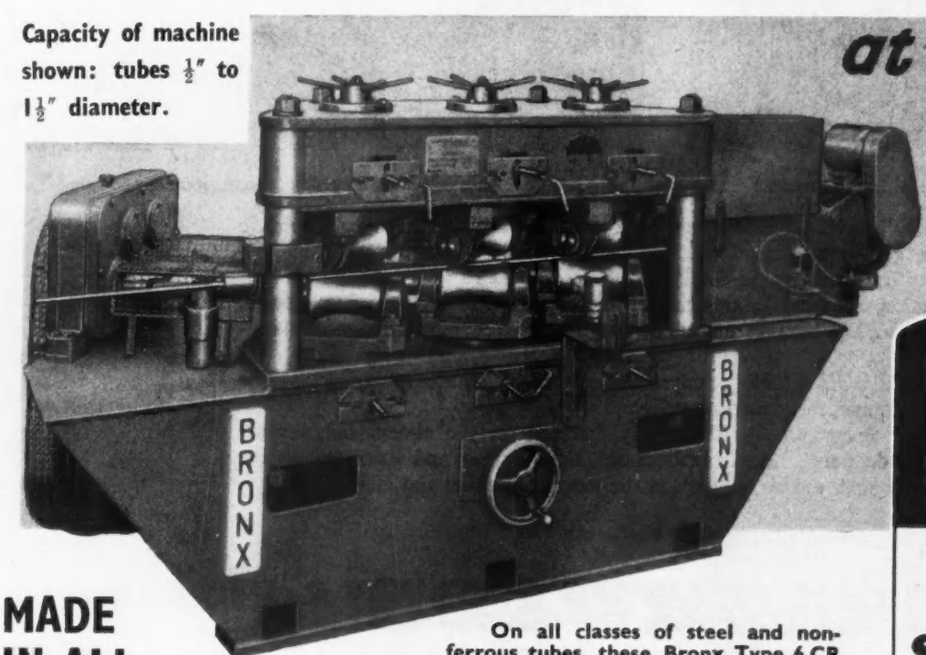

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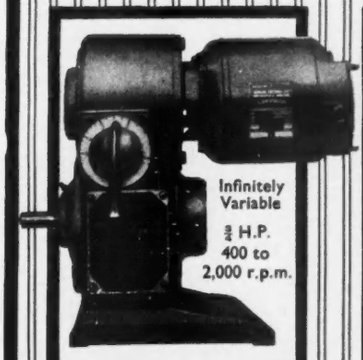

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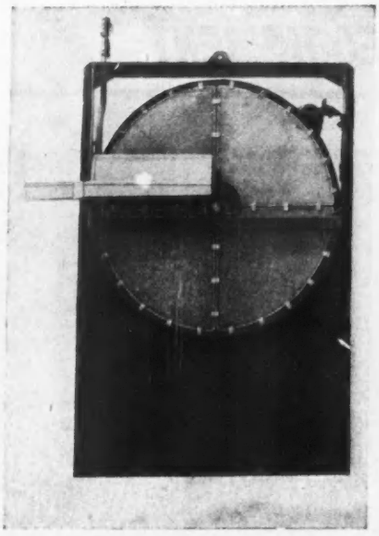

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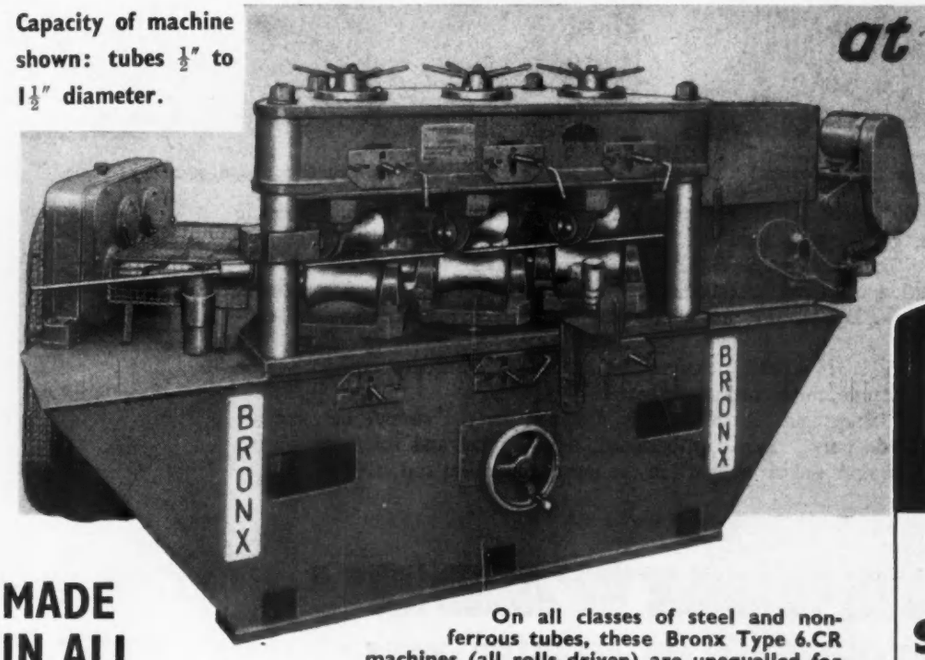

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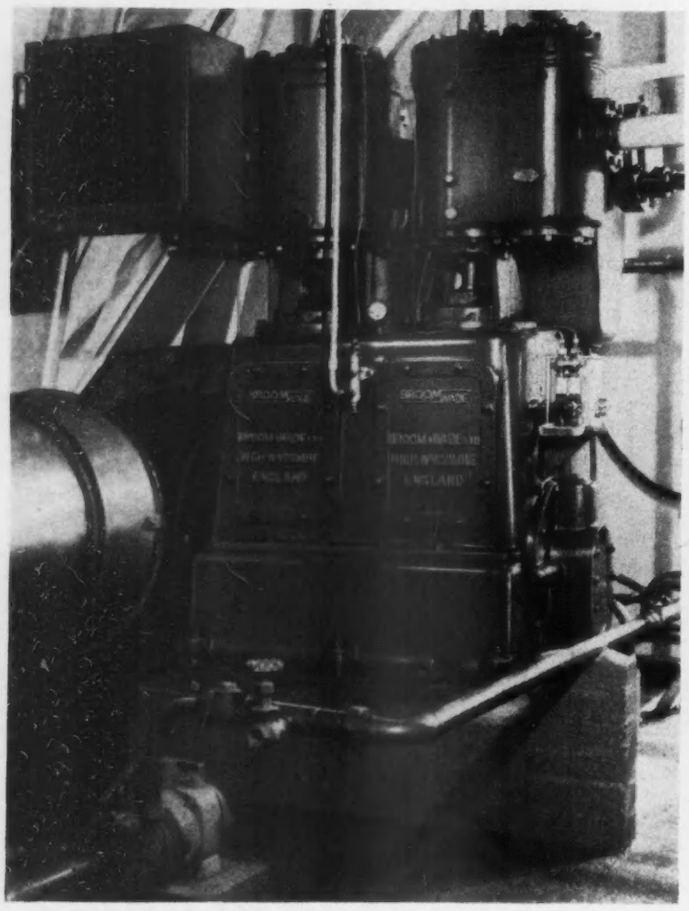
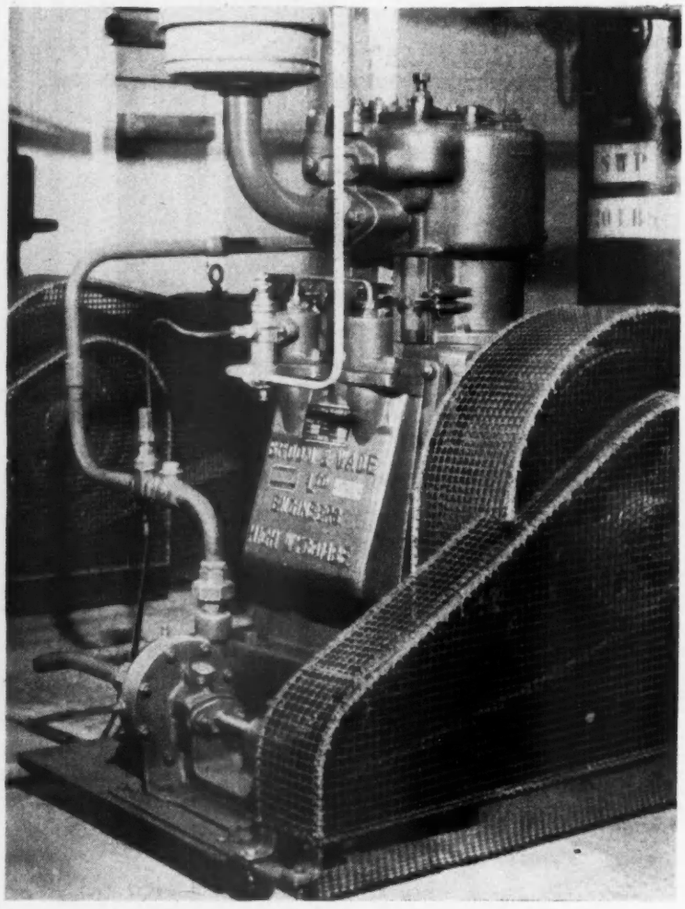


Type TS compressor. Output 322-1000 cu. ft. of free air per min.



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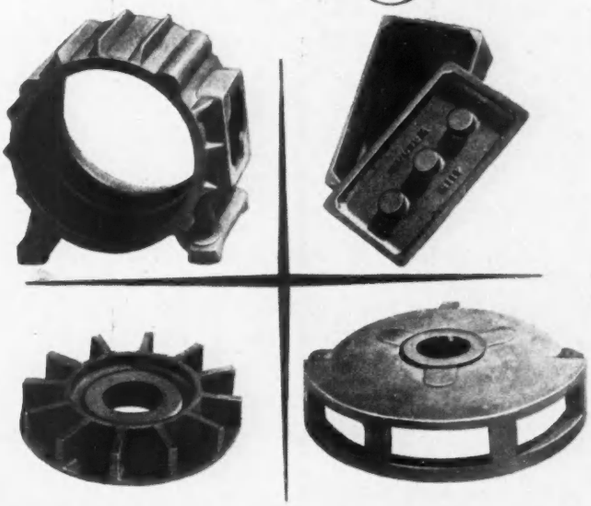

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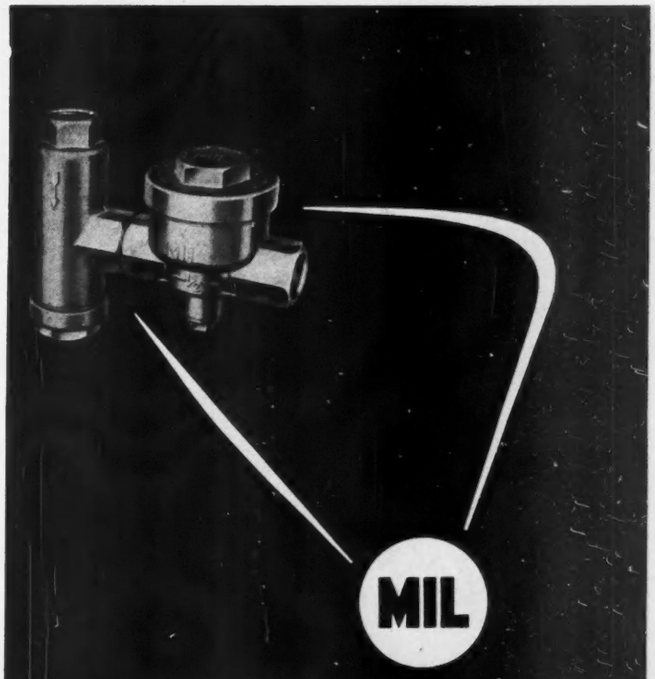

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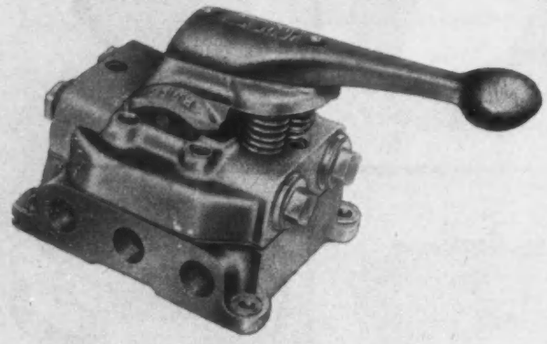

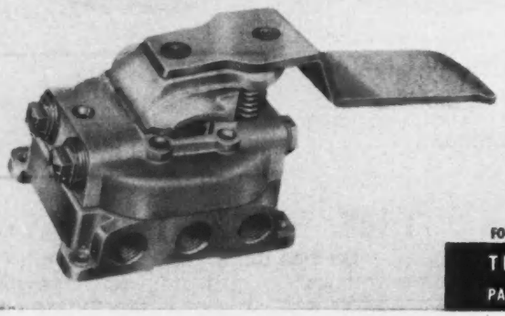

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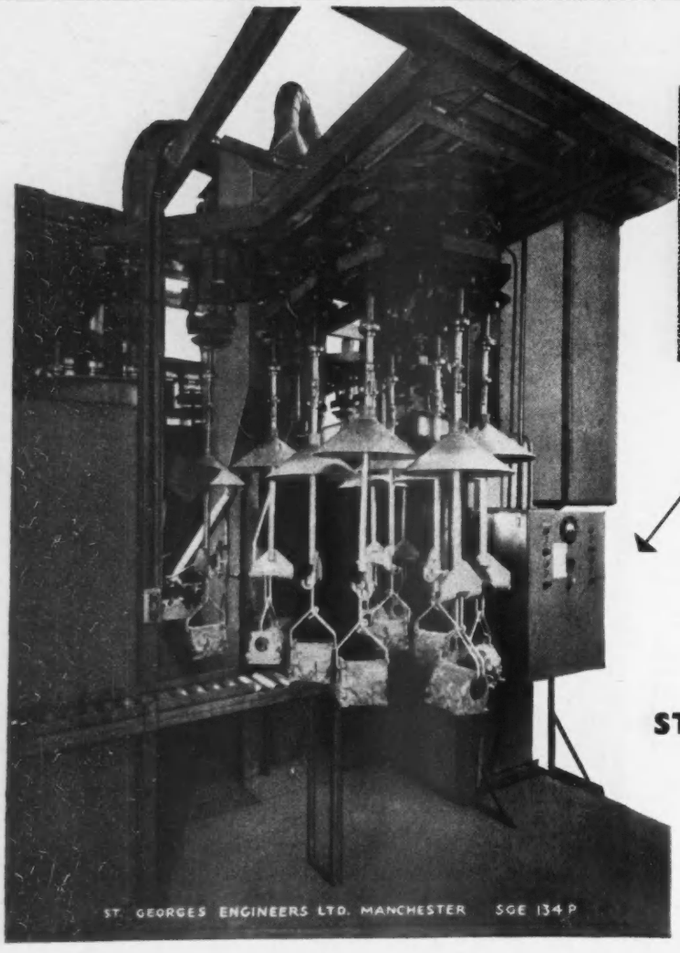

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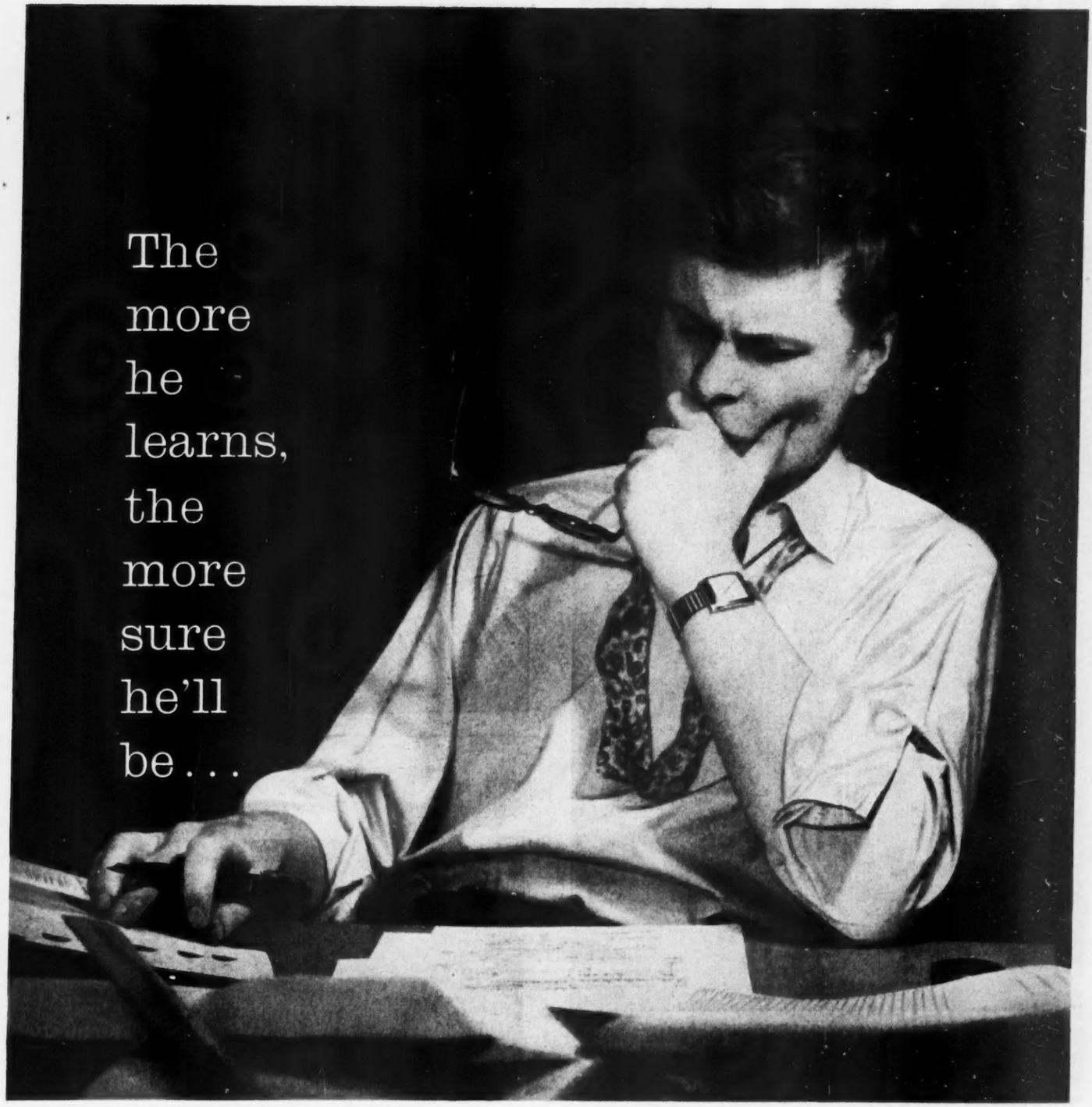

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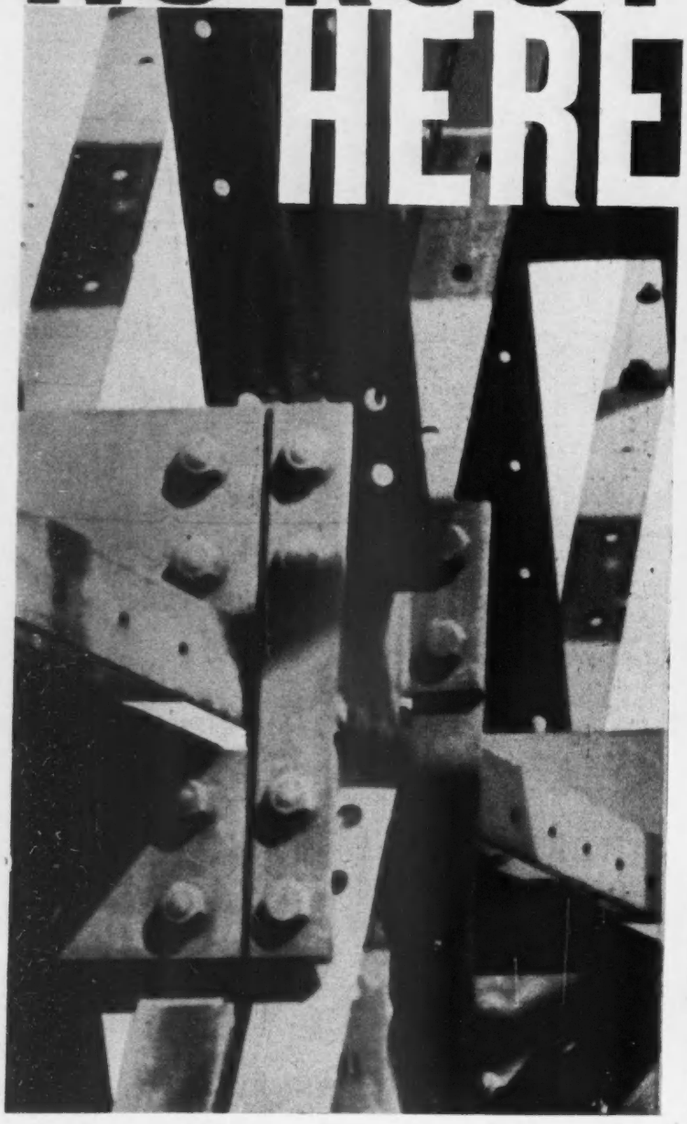

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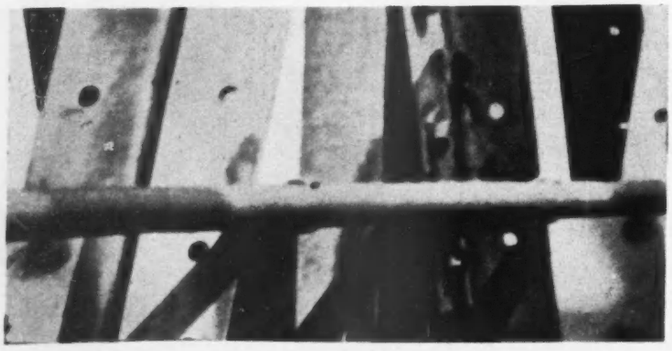

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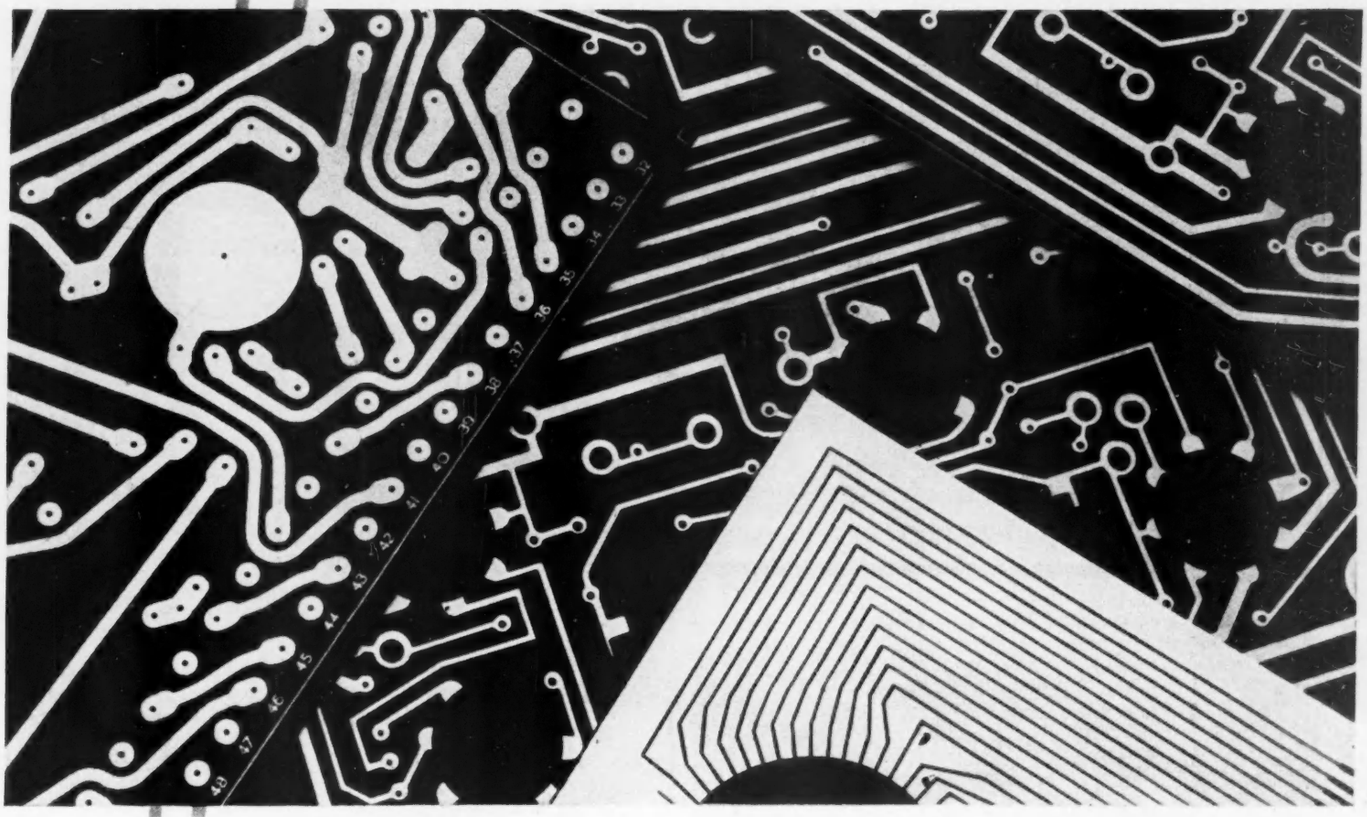

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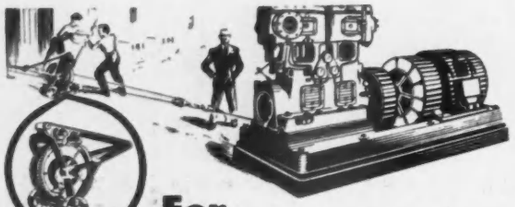

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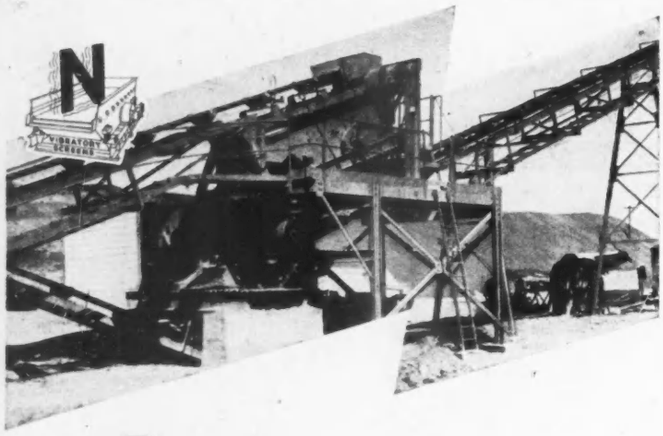

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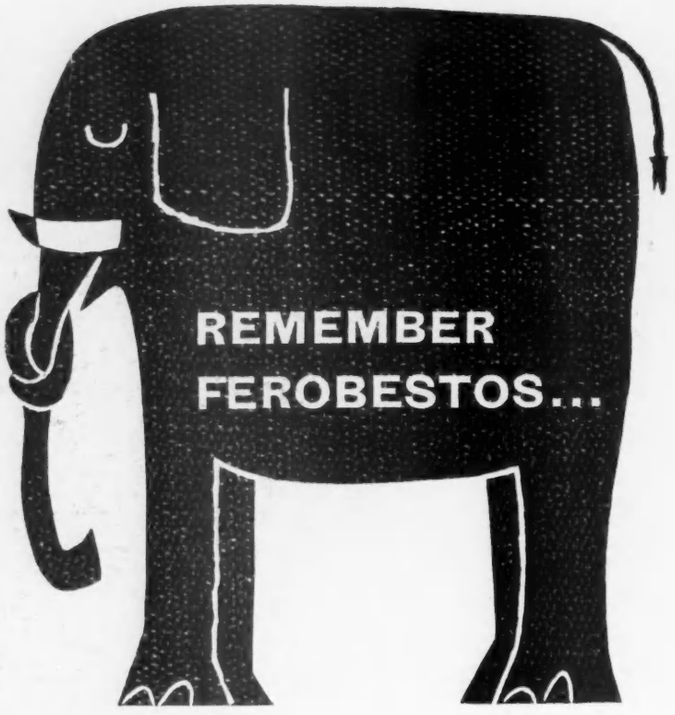

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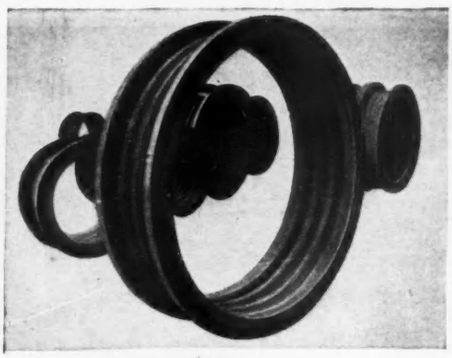

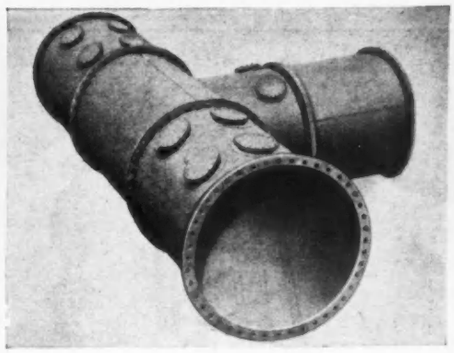

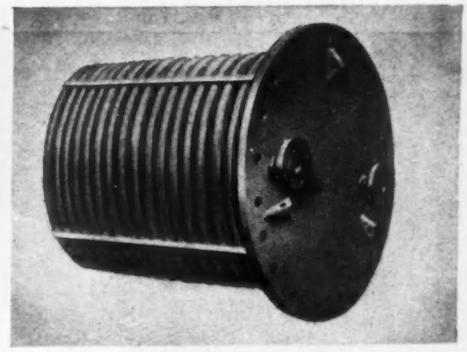

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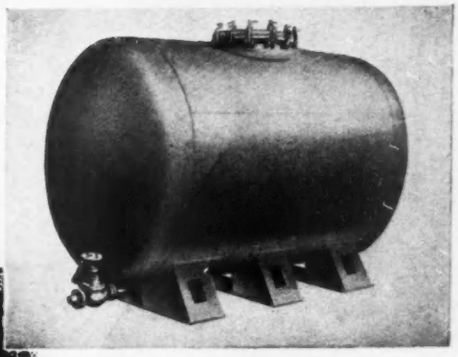

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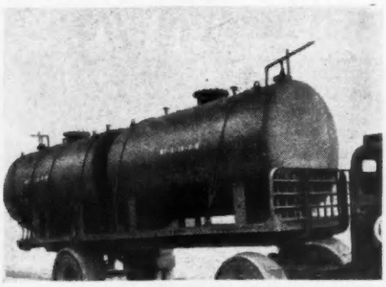

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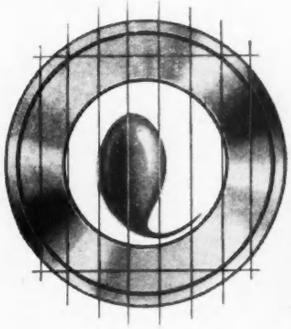

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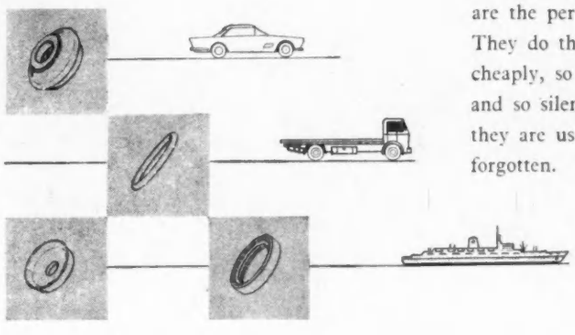

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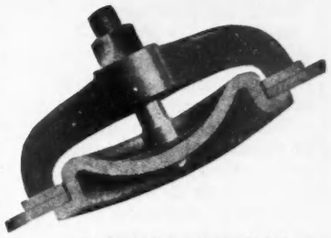

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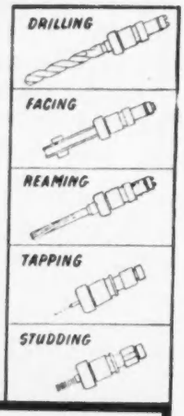

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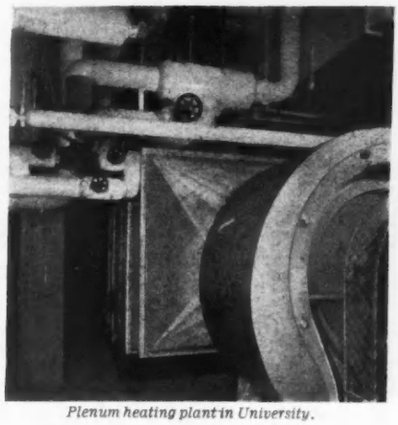

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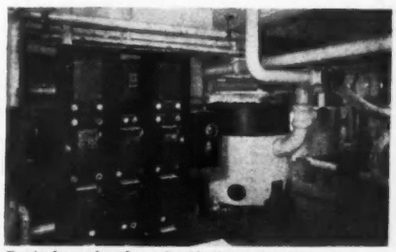

Control panel and gas-fired boiler in departmental store.

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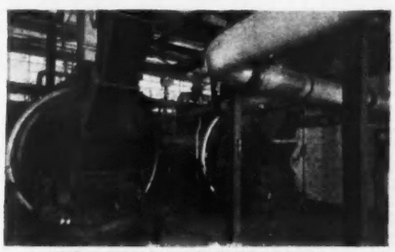
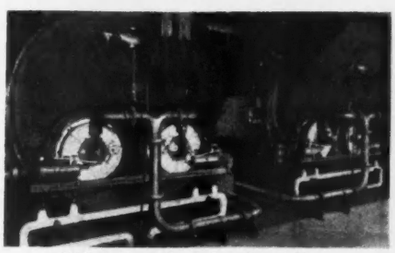
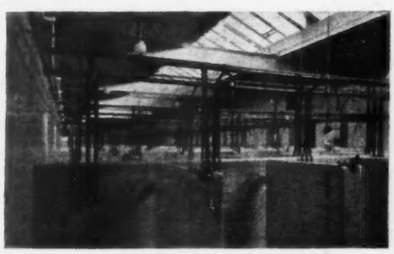


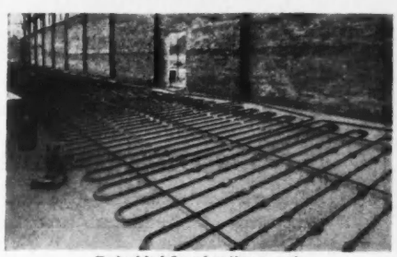
High pressure hot water boilers in factory.



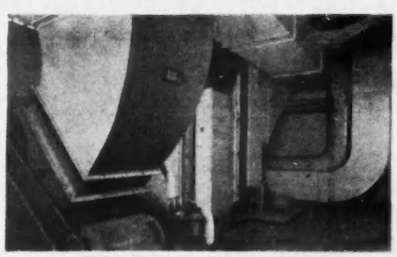
Oil burning equipment on steam boilers.



Hot water service shower ranges.



Embedded floor heating panels.



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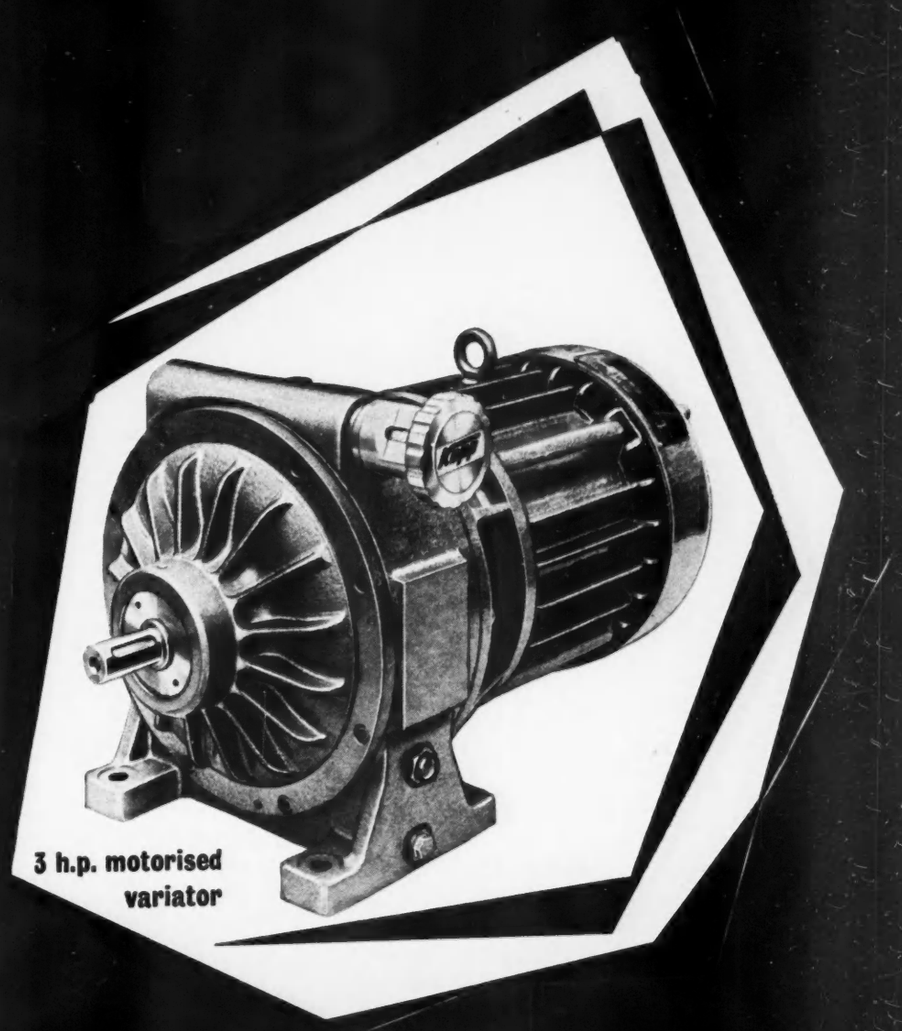

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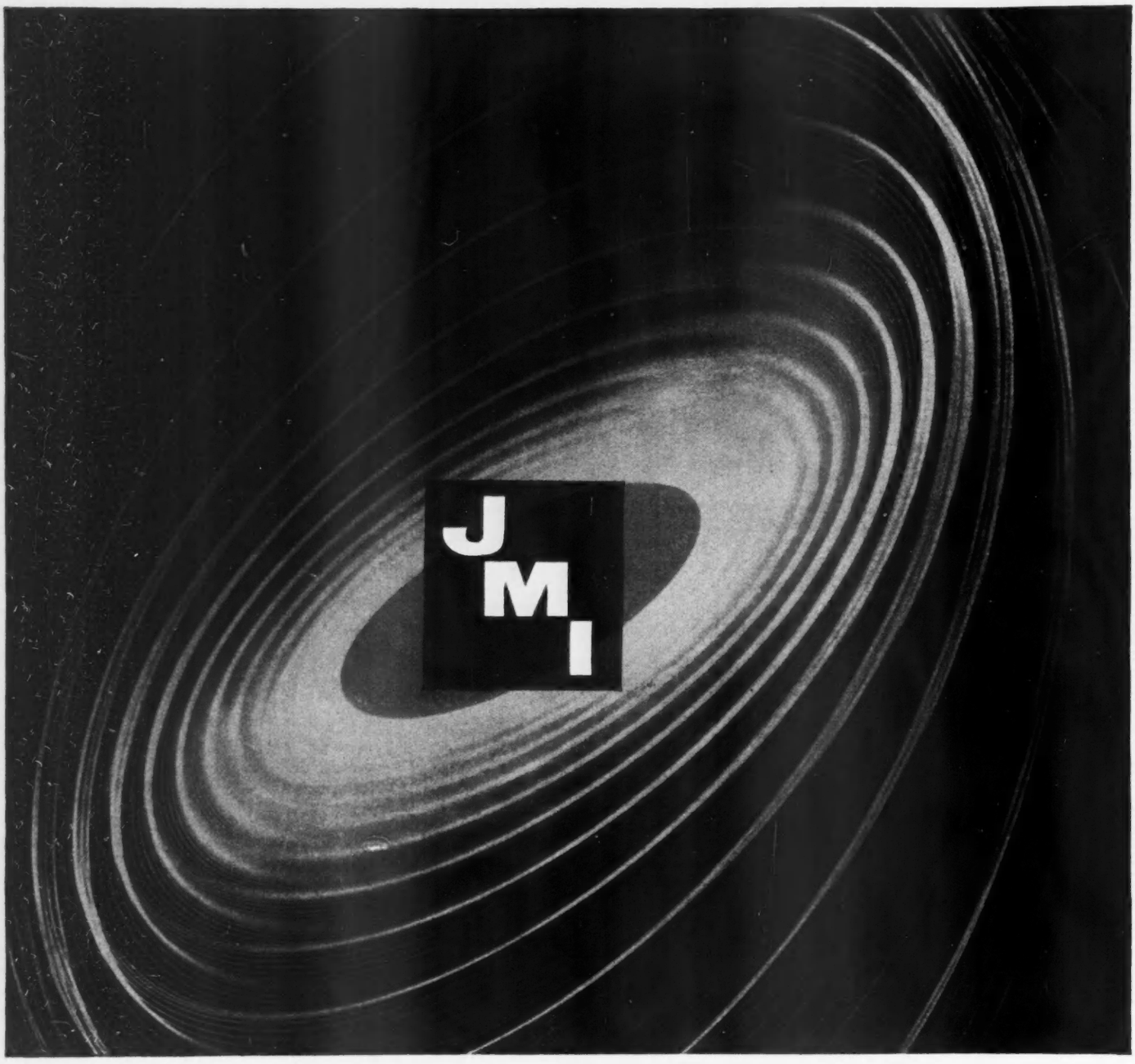

Scrutiny of youth

It is certainly the prerogative—and almost the duty—of each generation to question the ideas and loyalties of its predecessors. Were it not so progress would be slow indeed.

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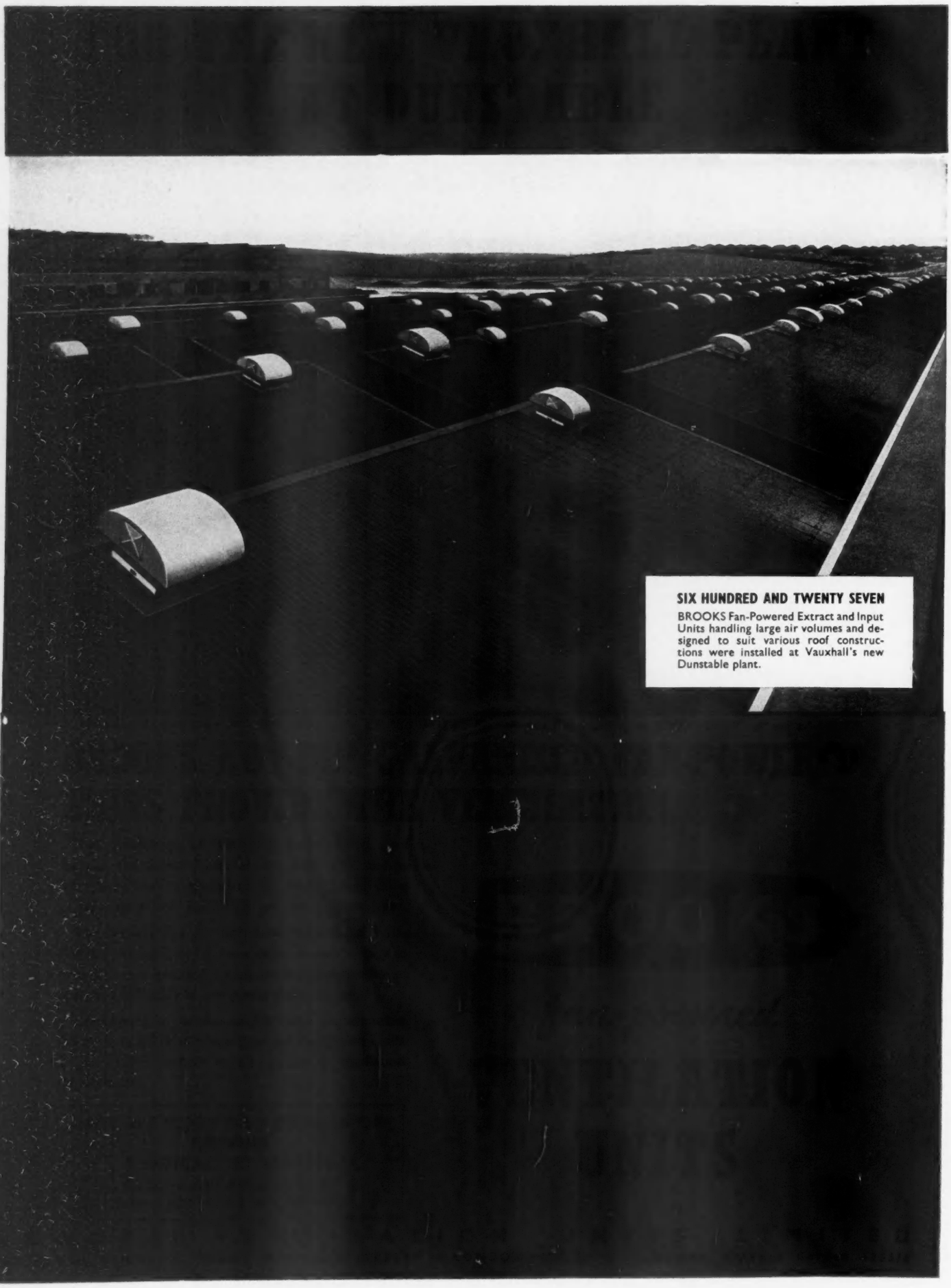

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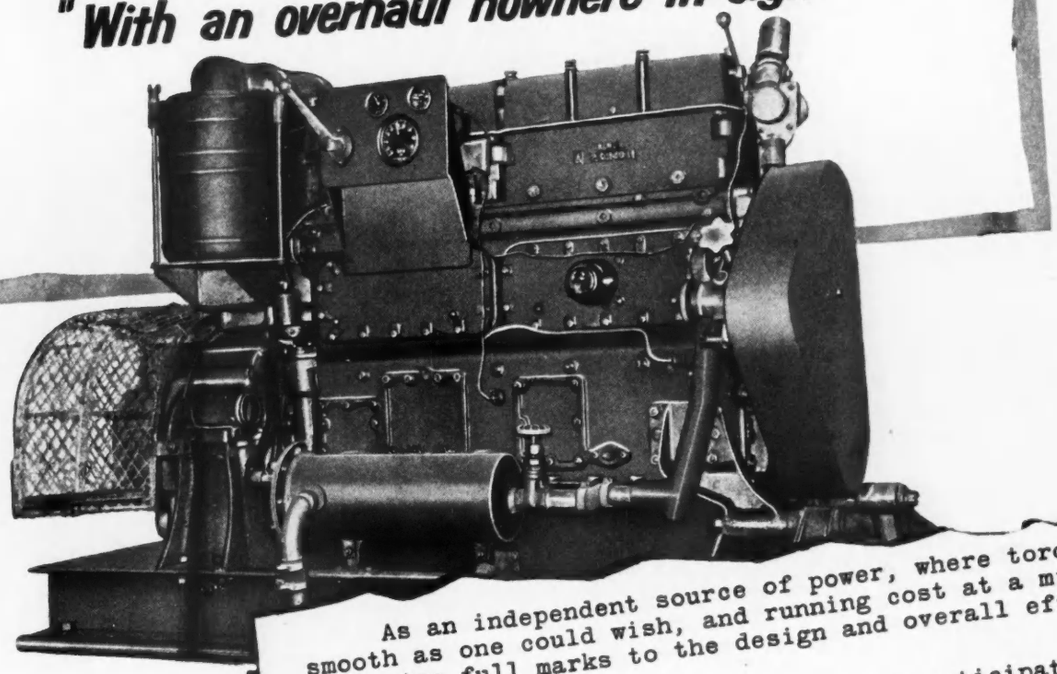

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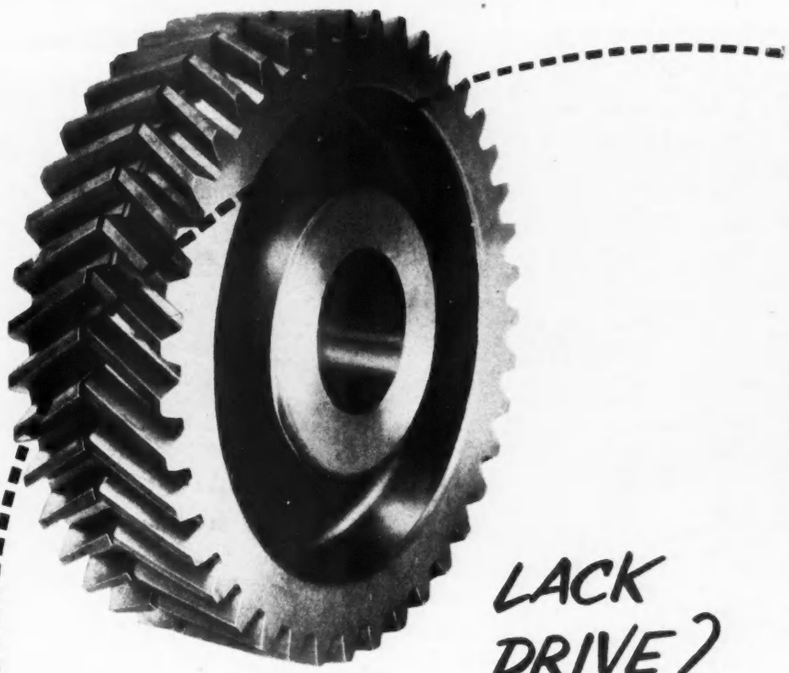

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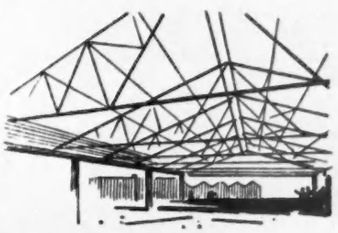

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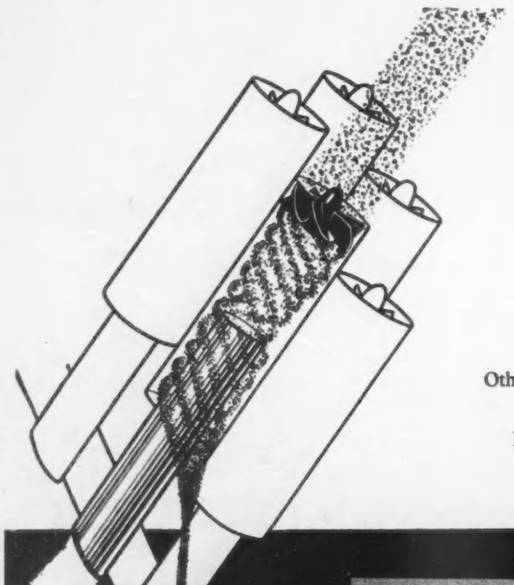

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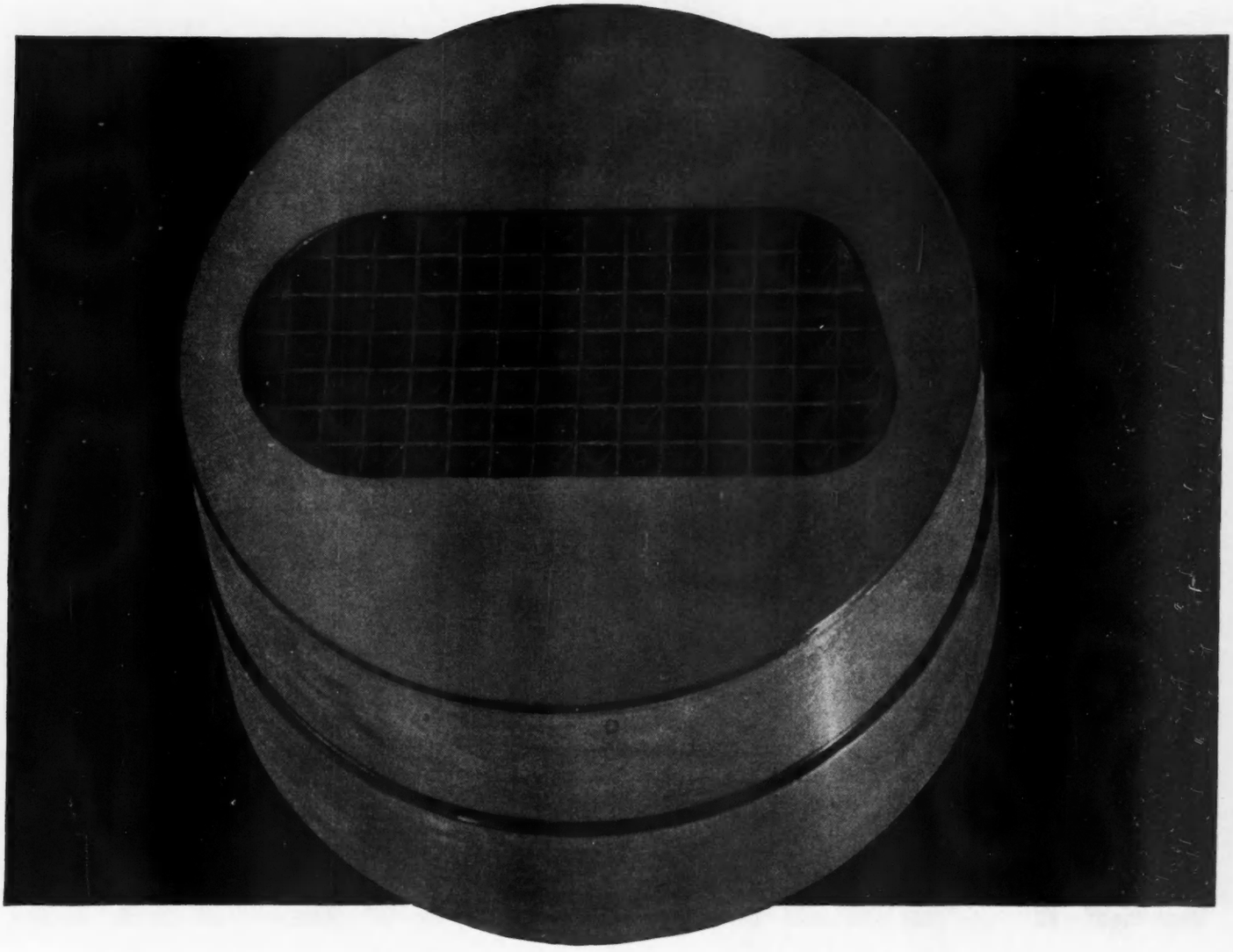

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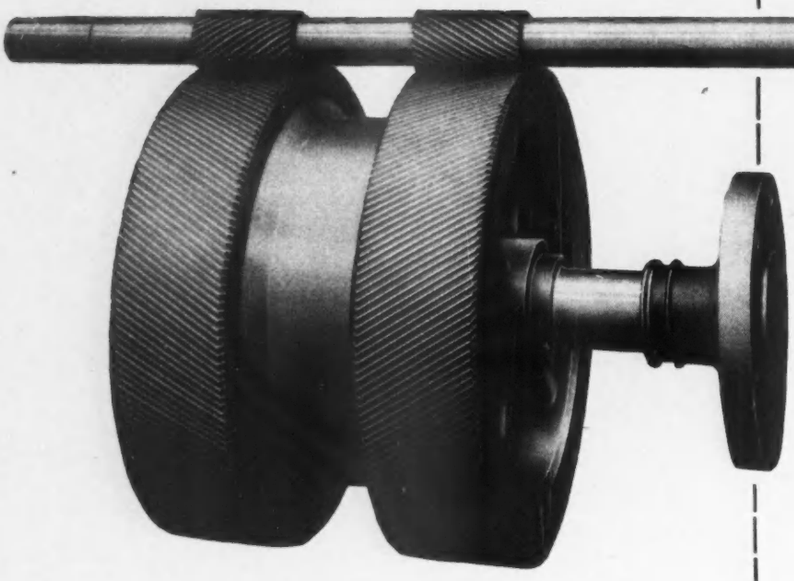

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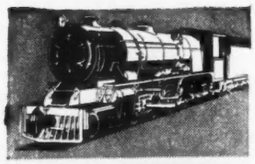

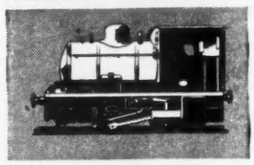

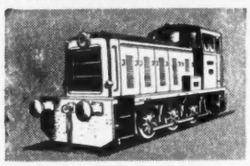

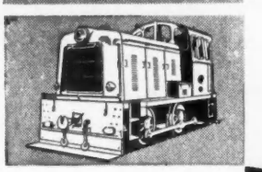

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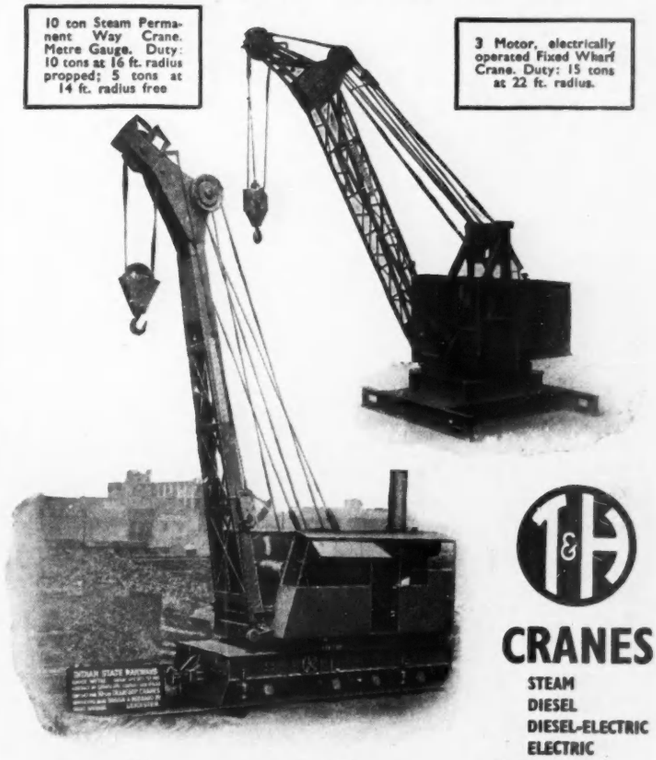

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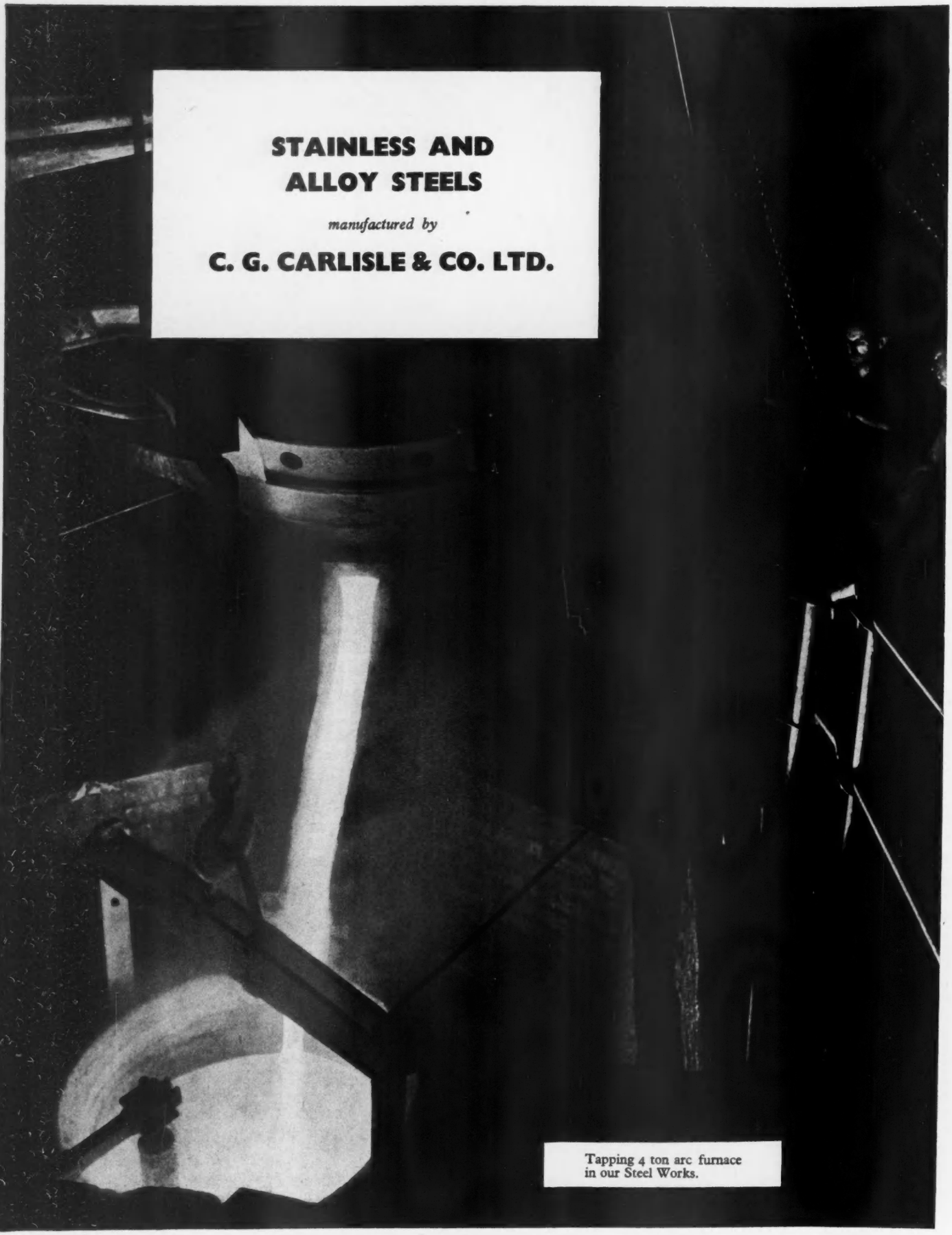

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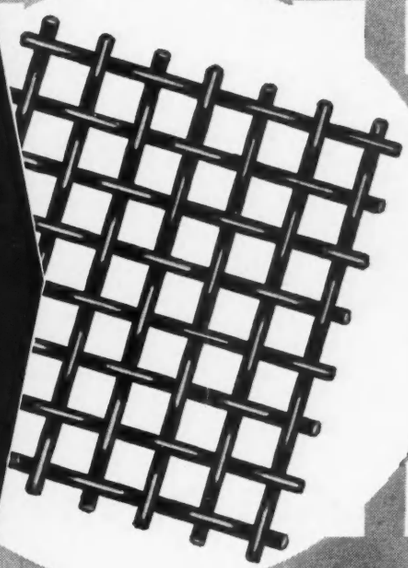

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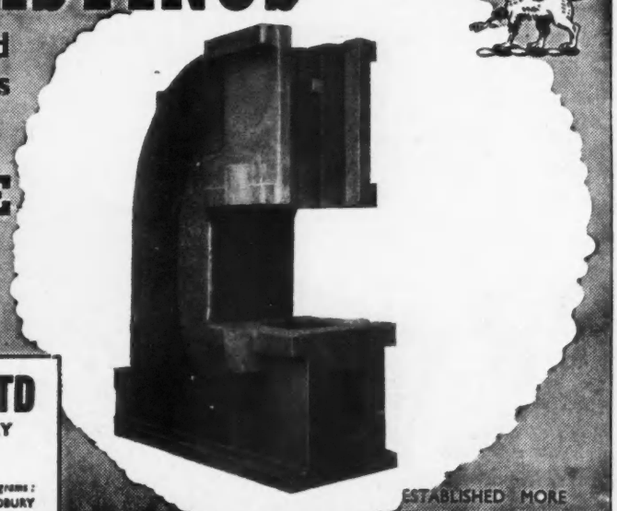

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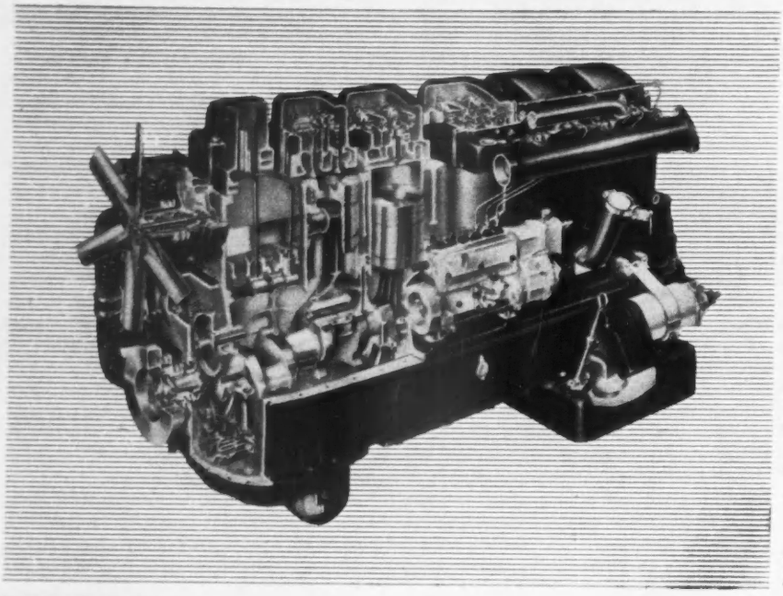

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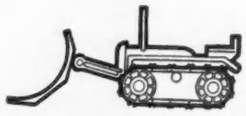

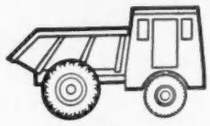

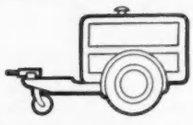

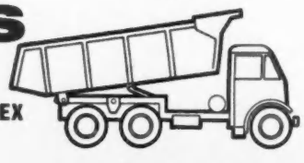

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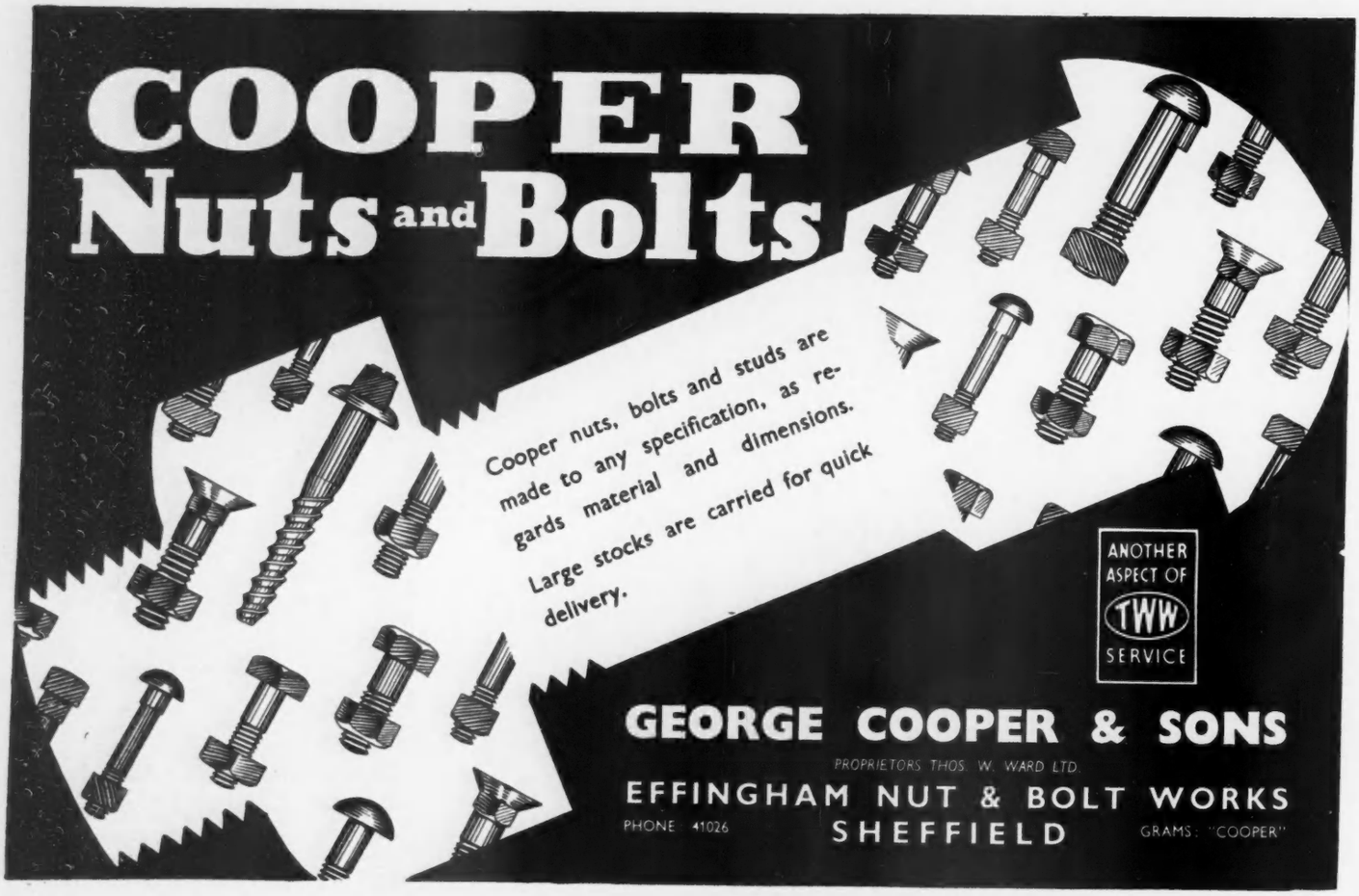

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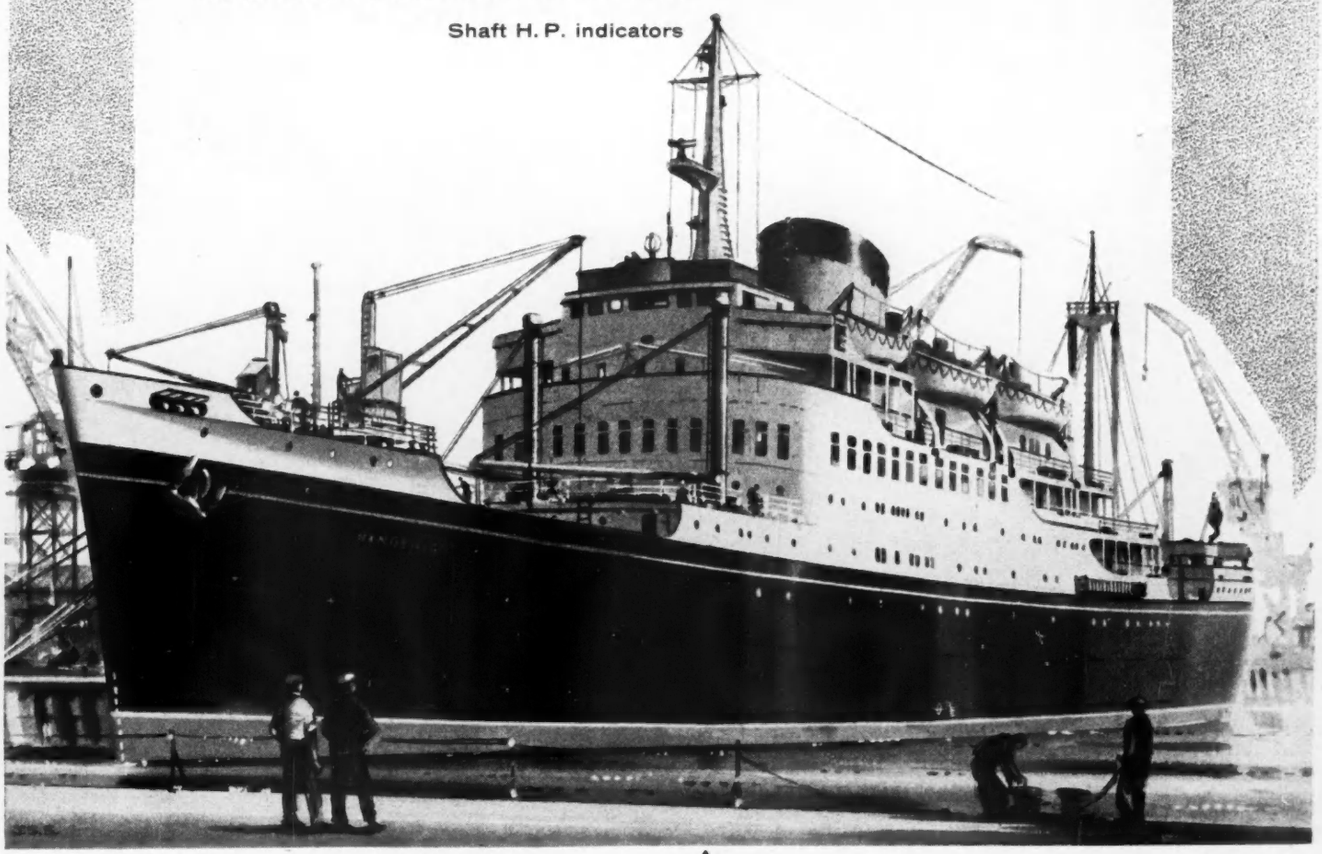

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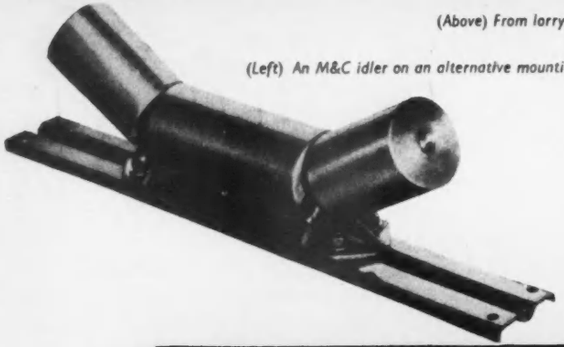
(Left) *An M&C idler on an alternative mounting—a corrugated idler-board.*



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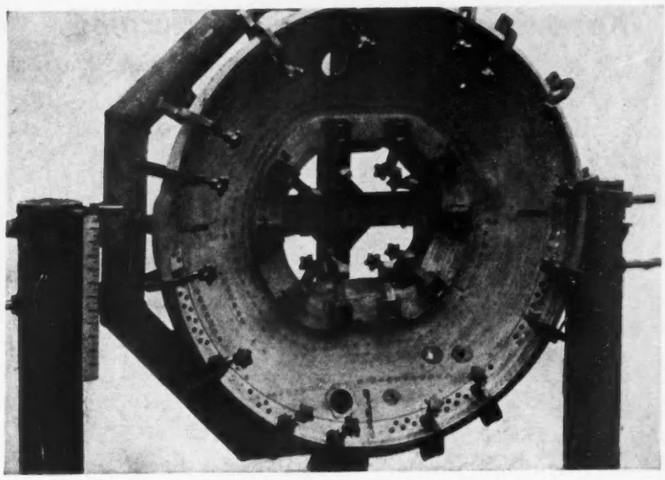

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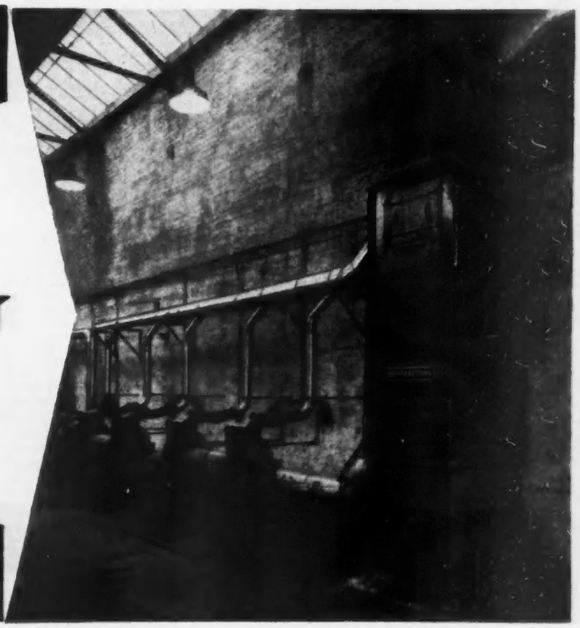

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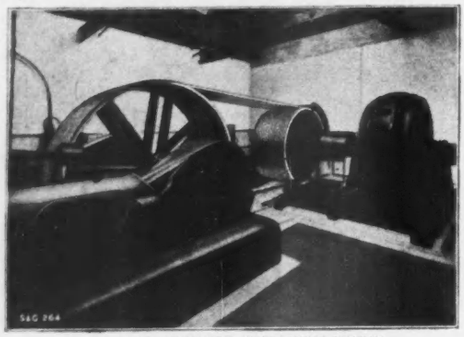

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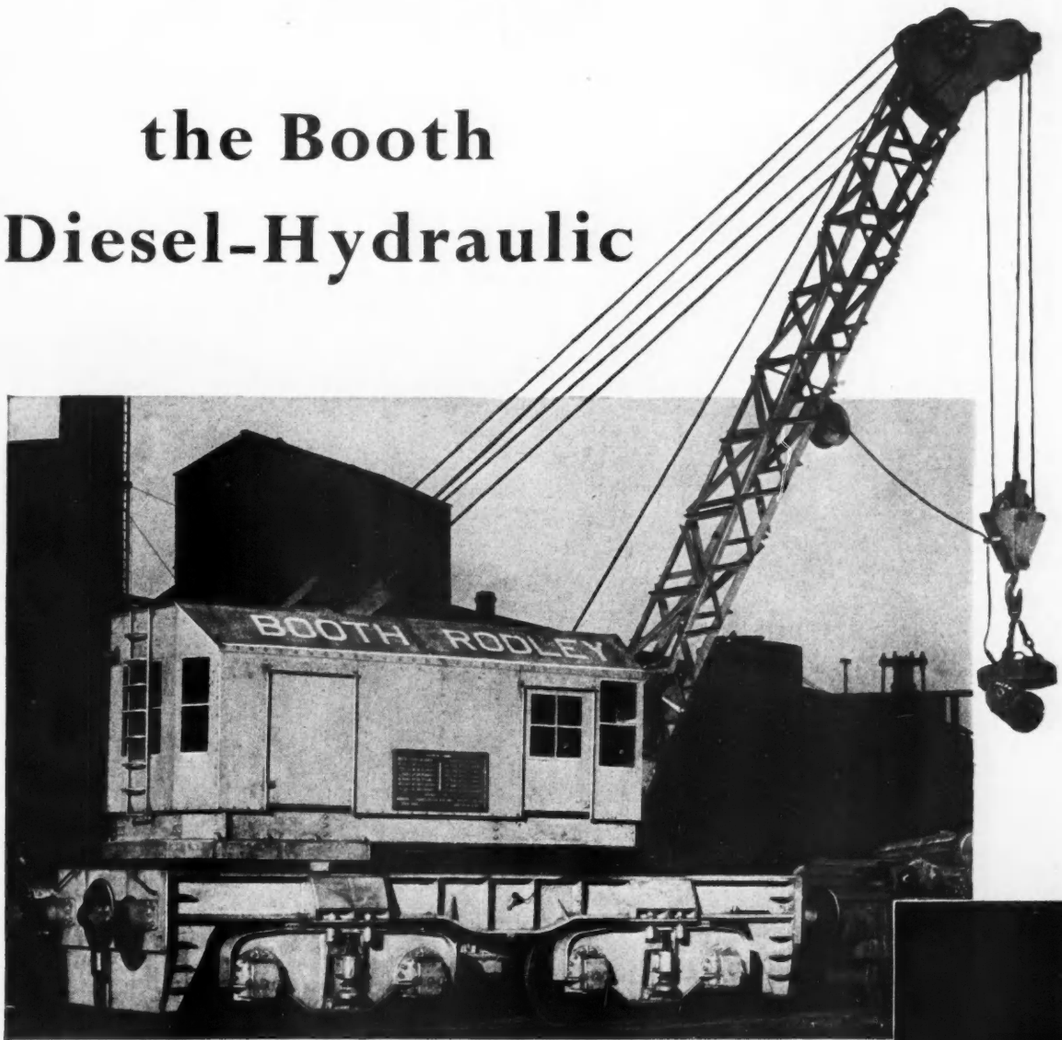

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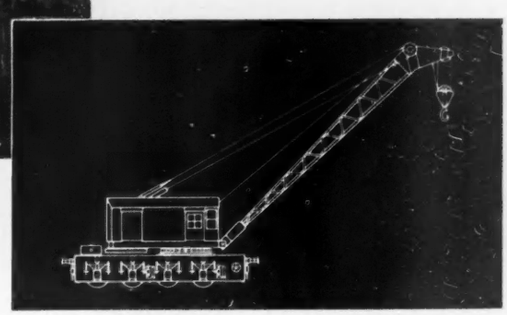

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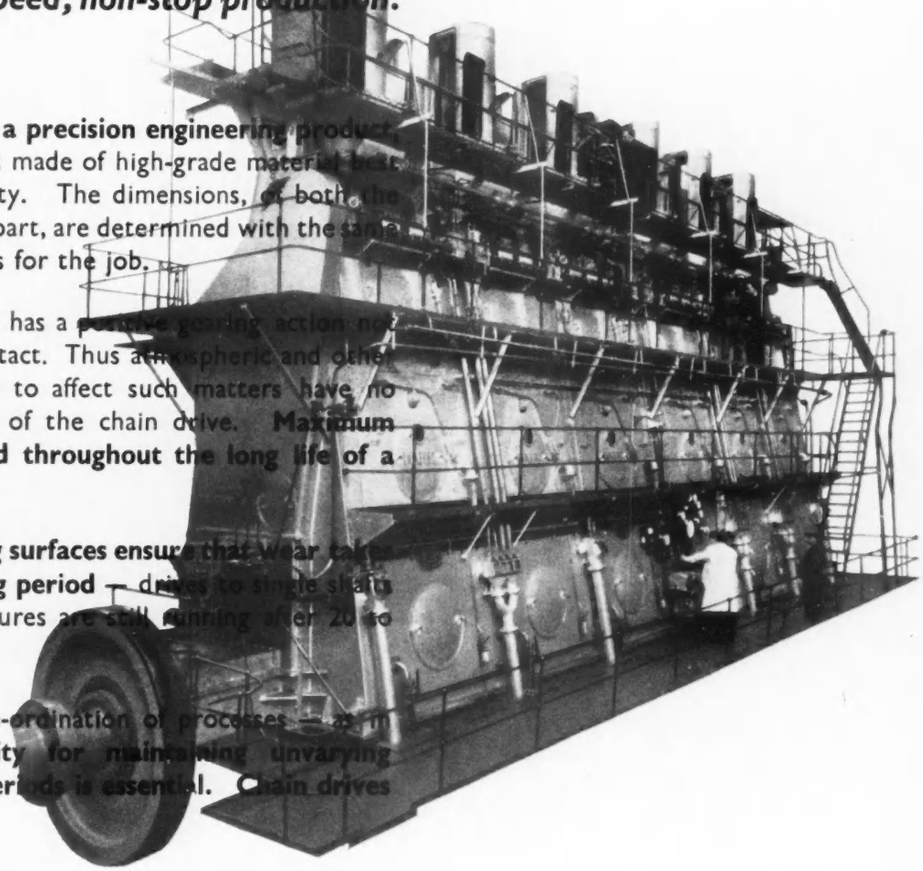

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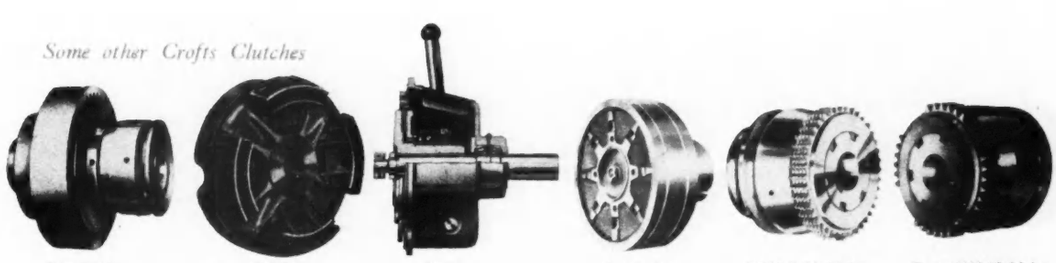

Patent RO Disc Clutch Publication 5740

DS Rim Clutch Publication 154

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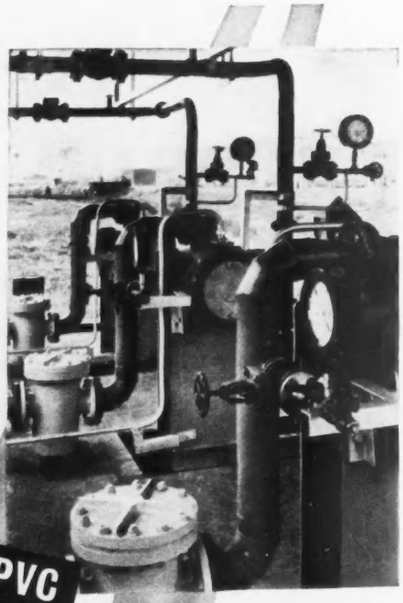

High Impact PVC tubing made by Extrudex Ltd, Bracknell, using Geon RA170. Photographs taken at The British Petroleum Co. Ltd Refinery, Isle of Grain.

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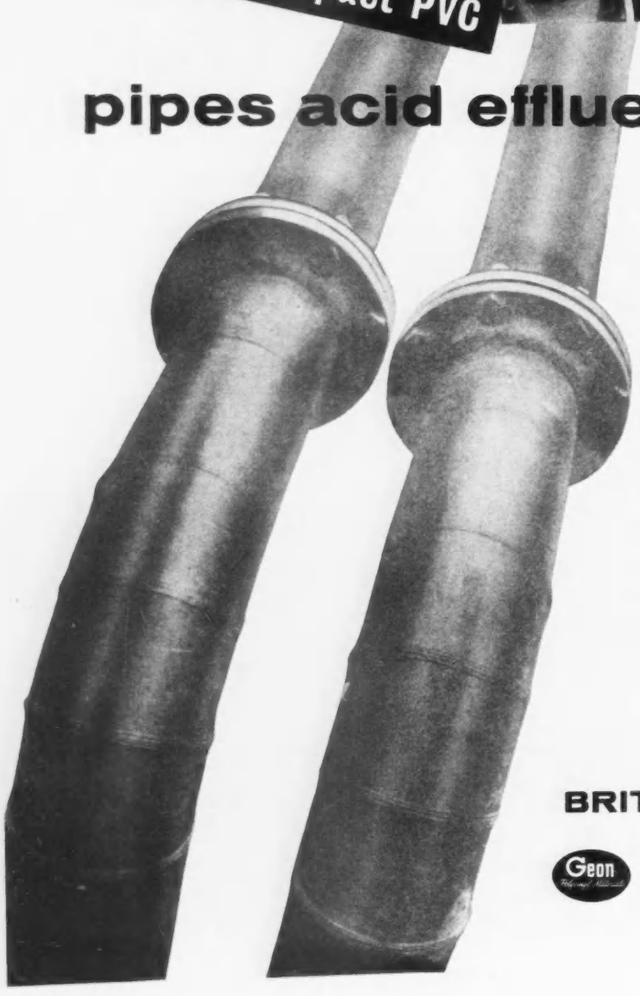

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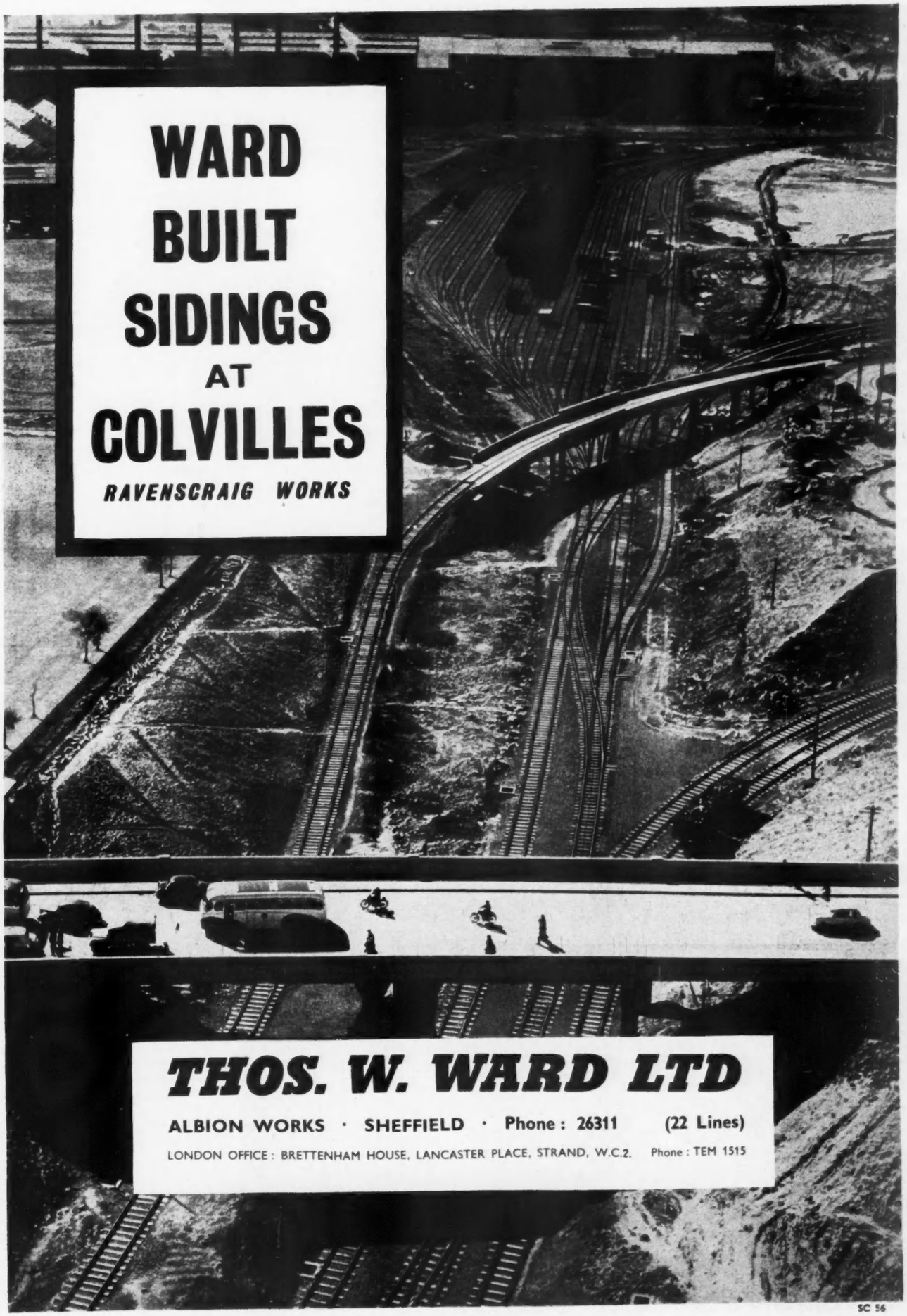
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- Every bar welded . . no rivets to work loose.
- Weight carrying with minimum depth and weight.
- Non-slip serrated tread.
- Any width or length.
- Spaced bars permit light and air circulation and also easy painting and cleaning.

With acknowledgements to the North Western Gas Board to whom we are indebted for the privilege of taking this photograph.

STANWELD ENGINEERING CO. LTD. Roundthorne Industrial Estate, Wythenshawe, Manchester 23
Tel: Wythenshawe 5555 (4 lines)

THE
SKERNE WORKS
LIMITED
ALBERT HILL, DARLINGTON
Tel: DARLINGTON 5612

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PRESSINGS
PRESSED SECTIONS
COLD FORMED SECTIONS
FABRICATIONS
MACHINED PARTS
IN ALL METALS

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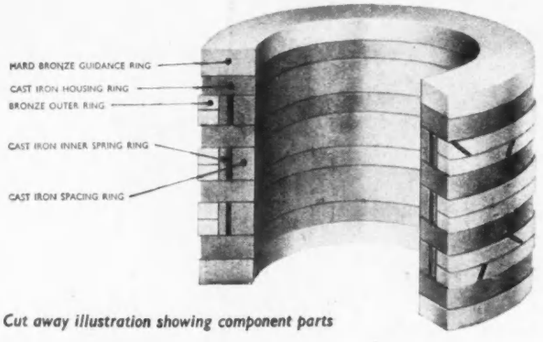
All enquiries promptly dealt with

STANDARD'S
BUILT-UP PISTON ASSEMBLY
For HYDRAULIC WORK AND HIGH PRESSURE SEALING

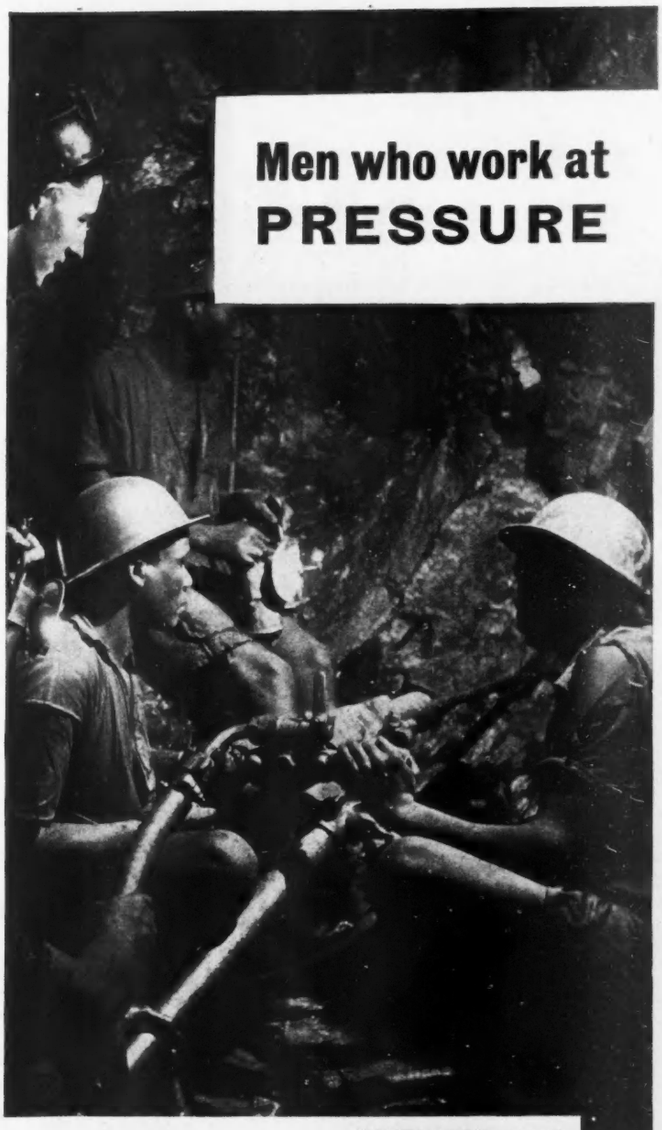


Cut away illustration showing component parts

ADVANTAGES OF STANDARD'S BUILT-UP PISTON ASSEMBLY

- All faces of assembly precision ground, permitting clearances to be reduced to a minimum.
- No possibility of ring distortion due to springing over solid piston.
- Any length of assembly can be built up to suit customers' requirements.

THE STANDARD PISTON RING & ENGINEERING COMPANY LIMITED **Established 1893**
PREMIER WORKS · DON ROAD · SHEFFIELD 9 · ENGLAND
Telephone: Sheffield 42076-7-8 (3 lines) *Telegrams: Ocean Sheffield 9*



know the value of reliable and accurate
VALVES

Automatic plate and disc valves are our particular concern. It's astonishing how many different versions of these vital components we have produced in the last seventy years. Our experience is unique—and is at your service.

***Your** valve problems are **our** business*

THE
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COMPANY LIMITED
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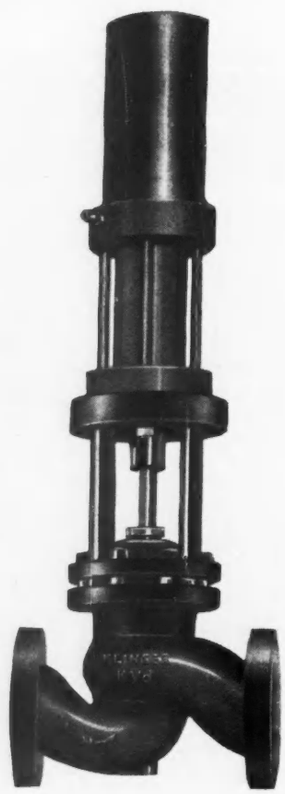
THE AIR-OPERATED KLINGERMATIC VALVE

gives a rapid opening and closing. Control of the valves is provided by a small hand-operated valve or push button, which can be situated 100 ft. or more away. A number of valves can be operated simultaneously by the same control, or a single valve can be controlled from more than one station.

Klingermatic

REMOTE CONTROL PISTON VALVES

The Klinger Piston Valve readily lends itself to remote control by air and hydraulic operation, and as such Klingermatic Air or Hydraulically Operated Valves are ideally suited for remote control of filling lines, emergency valves, drop-out valves, etc.



THE HYDRAULIC-OPERATED KLINGERMATIC VALVE

gives positive control in any position and gradual opening and closing. Control of the hydraulic valves is provided by oil pressure, generated by a pump, which is transmitted to the operating cylinders through metering, reversing and selector valves. The selector valves can be either hand or electrically operated.

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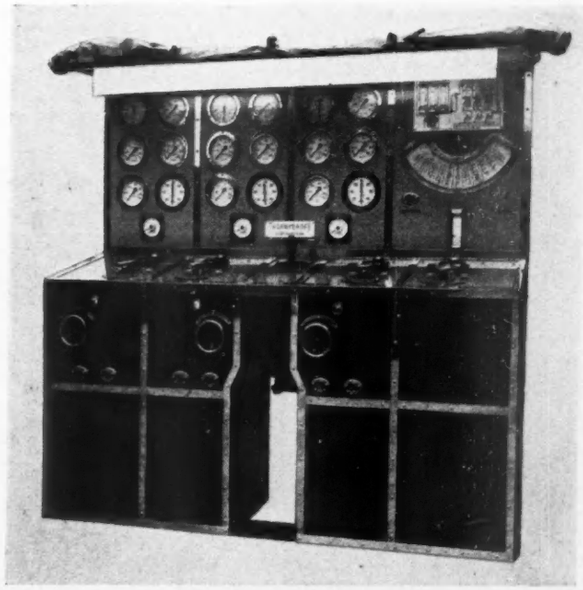
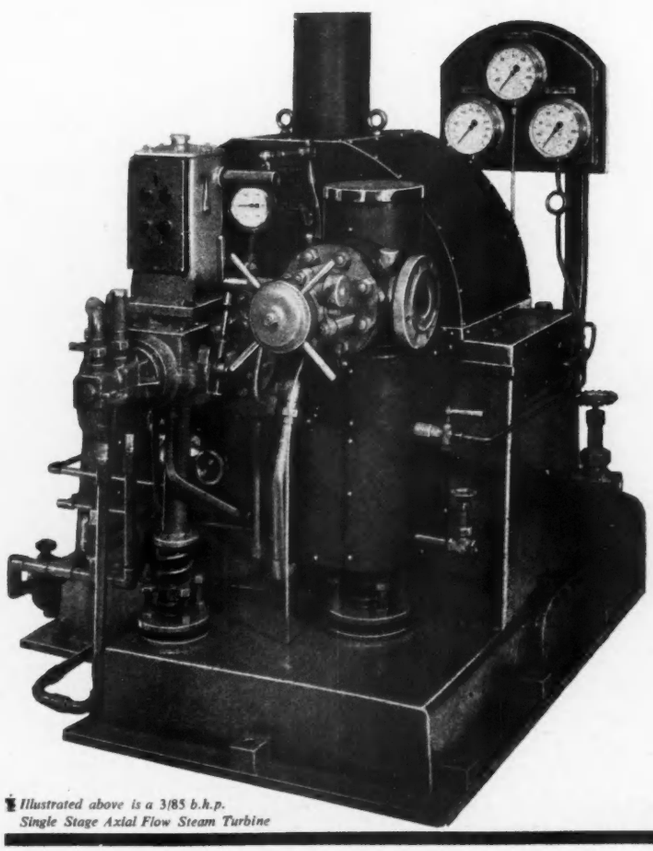
OIL FUEL BURNING EQUIPMENT

The demand for Thornycroft Oil Fuel Burning Equipment for Marine and Industrial installations continues to increase.
With over forty years of experience and the results of continuous experiment and research we are able to offer oil fuel burning equipment which is highly efficient, economical and safe, and like all Thornycroft productions, a good engineering job. Up to 3,500 seconds fuel oils can be burned cleanly and efficiently. Shown here is one of the Combustion Control panels which form part of the Thornycroft Oil Burning system in the *Queen Mary*.

For particulars of Marine equipment write for publication SEB.89A which includes a questionnaire for completion and return to us: SEB.99 gives details of Industrial equipment.



JOHN I. THORNYCROFT & CO. LIMITED, WOOLSTON WORKS, SOUTHAMPTON



Illustrated above is a 3/85 b.h.p. Single Stage Axial Flow Steam Turbine

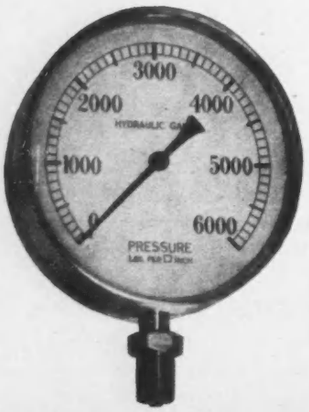
Mirrlees'

STEAM TURBINES

The range of Mirrlees Steam Turbines includes units of both radial and axial flow types for powers up to 300 b.h.p. and 800 b.h.p. respectively, providing at reasonable cost, power for driving Pumps, Fans, Blowers, Compressors, etc.
Steam Turbines are also very suitable for use as standby units; they can be equipped with controls to bring them into operation automatically in the event of a failure of electrically driven units.

THE MIRRLEES WATSON COMPANY LIMITED

Head Office and Works: SCOTLAND ST., GLASGOW, C.5
London Office: 38, Grosvenor Gardens, S.W.1



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OF EVERY DESCRIPTION AND SIZE

PRESSURE RANGE FROM 5-20,000 lbs. per sq. inch

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Highest Quality.
Send for Illustrated Catalogue.

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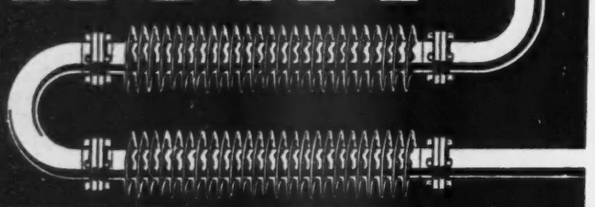
HUNT



Gilled Tubes & Heaters
HUNT & MOSCROP LIMITED
P. O. Box No. 8 MIDDLETON · MANCHESTER

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MANY SHEET METAL JOBS STILL REQUIRE SKILLED CRAFTSMEN — WE HAVE THEM
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GENERAL & INDUSTRIAL SHEET METAL WORKERS
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ALPHA WORKS, MILLWALL
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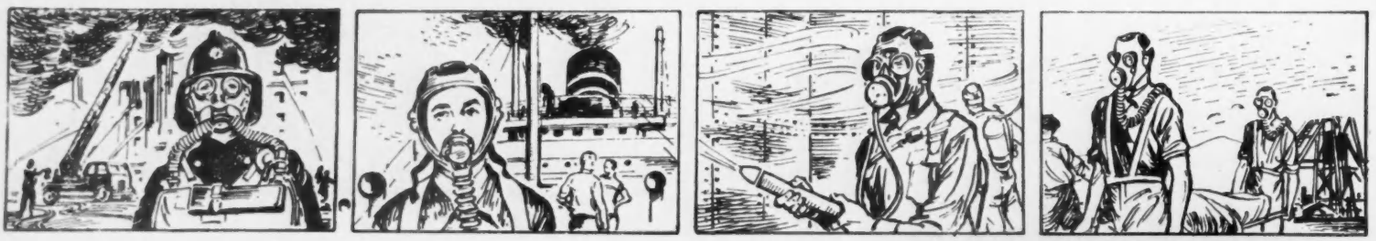
Whatever the hazard . . .



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ESTABLISHED 1819

AIR-FED PAINT SPRAYER'S MASK

Eliminating the need for costly extraction plant, this new air-fed mask gives complete protection and breathing comfort to paint sprayers working indoors or outdoors. Since no part of the filter is exposed, it cannot become clogged, and is therefore ideal where the atmosphere is heavily loaded.
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An inner flange on the soft rubber facepiece ensures an airtight fit on all shapes of face. The movements of a man using this outfit are freer, since he requires no additional equipment. *Write for further details.*
SIEBE, GORMAN are long-established suppliers of all types of safety equipment to the Admiralty, the Public Services and Industry.

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TGA 17

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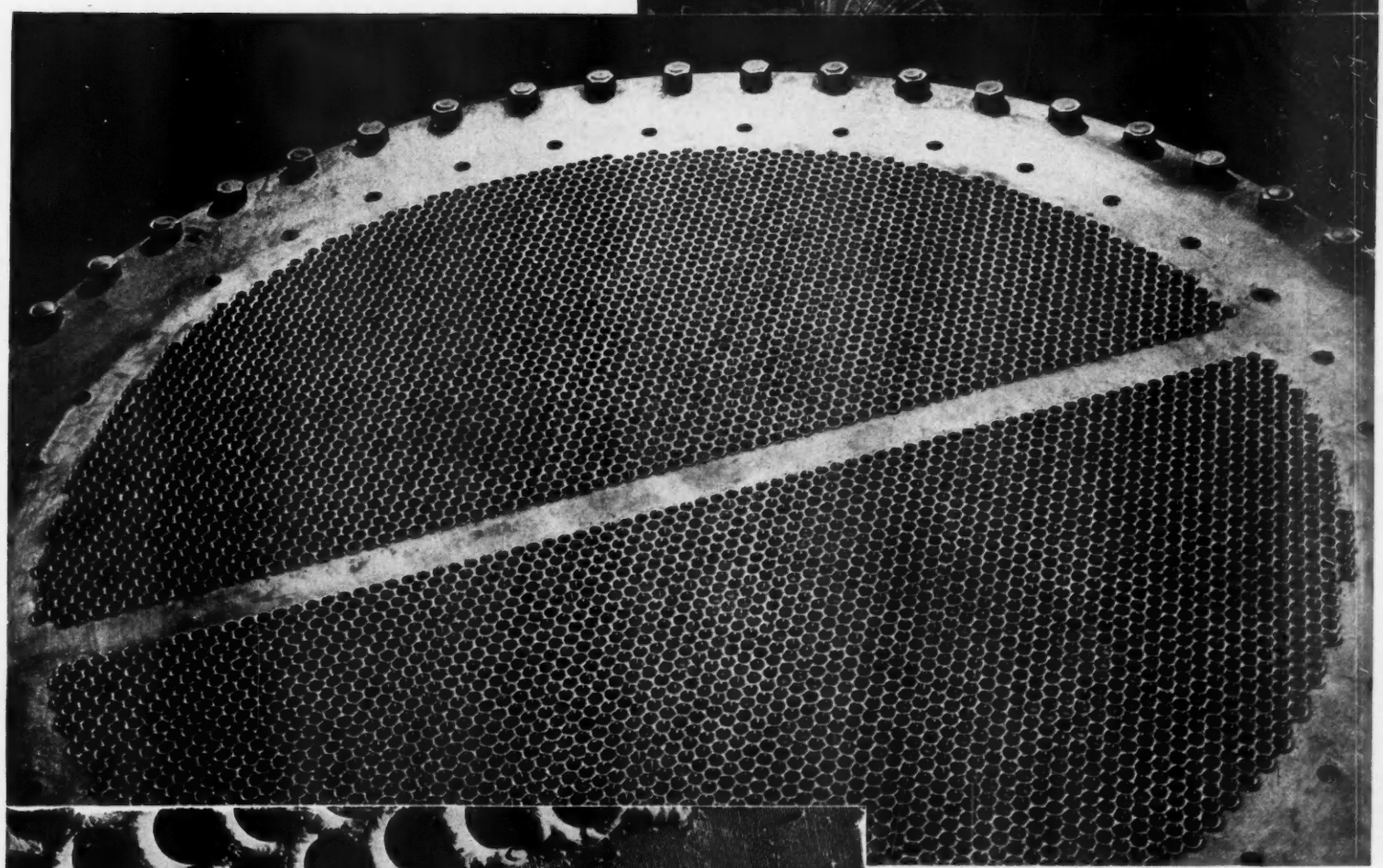

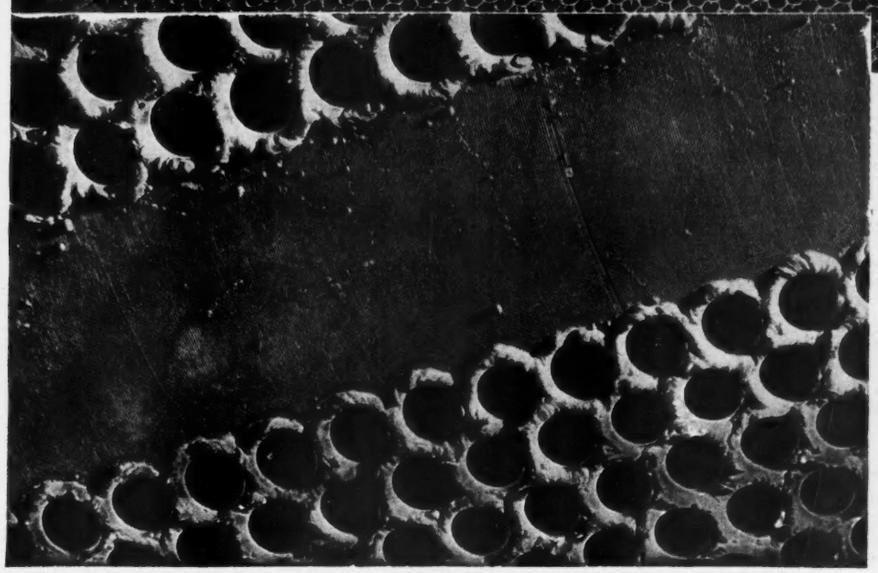

Tube plate for a Heat Exchanger, incorporating 5,518 tubes $\frac{3}{4}$ in. dia., and involving 1,078 footage of welding.

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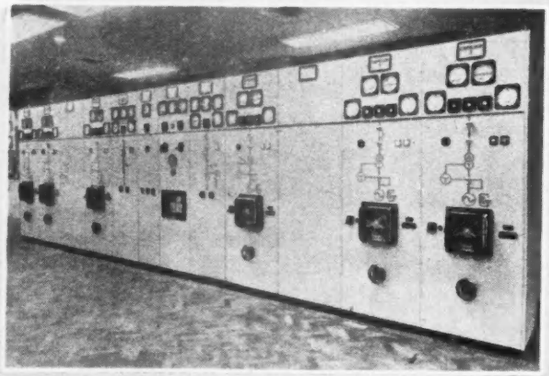
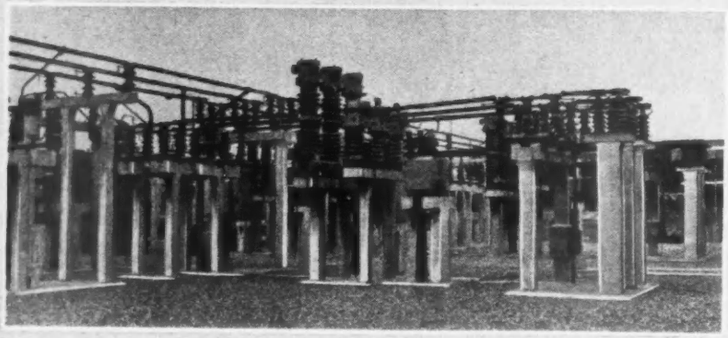
WITH SWITCHGEAR SUPPLIED BY REYROLLE

The 33-kV 1000-MVA small-oil-volume switchgear and ancillary equipment controlling the supply to the six 22,000-H.P. compressor-motors was manufactured and installed by Reyrolle



Photographs by courtesy of Rolls Royce Ltd.
Consulting Engineers: McLellan and Partners in association with Messrs. Merz and McLellan



Reyrolle

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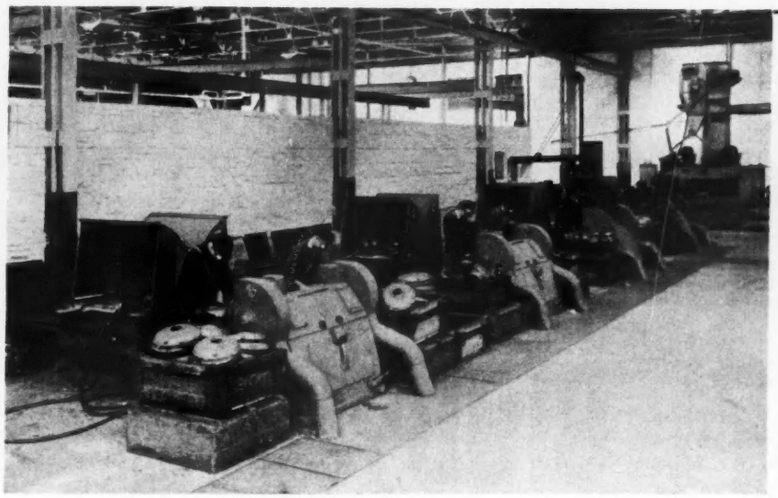

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IN THE NEW DRESSING SHOP OF

THE HILL TOP FOUNDRY CO., LTD. WEDNESBURY

includes

14 "DUSTROL" (REG'D) Fettling Benches

together with Hill Top 3 speed grinders incorporating B.S.C.R.A. hoods with all ducts underground and discharging to a wet collector with automatic sludge discharge.

We can supply ANY TYPE OF COLLECTOR, WET OR DRY, and so are in a position to give unbiased advice on the best system of collection to solve your particular problem.

"DUSTROL" Fettling Benches are designed and made solely by us. . . . . .

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SPECIALISTS IN DUST AND FUME REMOVAL FOR NEARLY 40 YEARS

MODERN SCIENTIFIC PENETRATING

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Insist on "LUSOL"

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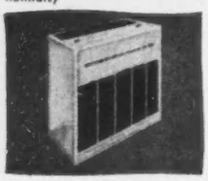
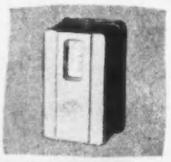
means automation in heating, ventilating or process control

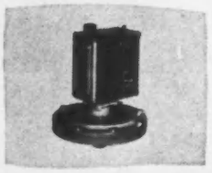
Air-conditioning cabinets for constant temperature and humidity



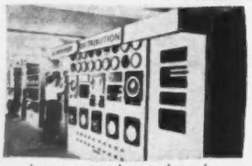
Delta Regulator (for boiler flue control)

Room Thermostat





Pressure Controllers



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Duct or Water Thermostat

Variator (for outdoor temperature control of indoor space-heating)

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If you are interested in automatic control, YOU should be on our mailing list
PLEASE TICK YOUR FIELDS OF INTEREST

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Thermocontrol manufacture and distribute a full range of controls and allied products. You, who are interested in this field, should know more about our equipment and services. We would be very pleased to give you full information and to put you on our mailing list. Just ask your secretary to fill in this coupon and post it to:—

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Company .....

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Thermo control INST. CO. LTD.

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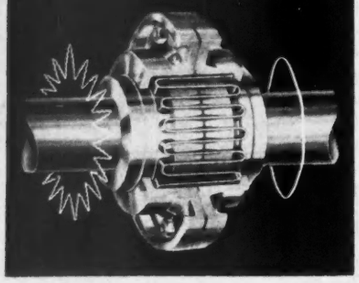
The most efficient couplings obtainable



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For nearly forty years Bibby Resilient Couplings have enjoyed an unexcelled reputation for efficiency and reliability and numerous Couplings supplied over thirty years ago are still giving trouble-free service.

The outstanding resilience of Bibby Couplings dampens shocks and vibrations, ensures smooth running of plant, eliminates breakdowns. Standard Couplings up to 7½" bore can be supplied from stock.

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SOLID STEEL DROP FORGED

all sizes from ¼" to 3" whit.

ARMSTRONG STEVENS & SON LTD.
WILLENHALL STAFFS.

ALZEN 305

Regd. Trade Mark B 752748

This 900 Ton Press

RELIES ON ALZEN 305 BEARING ALLOY

PAT. No. 725818

Alzen 305 Reduces Cost Halves the Weight and Lengthens Bearing Life

Alzen 305 White Bronze Bearing Alloy Brit. Pat. No. 725818 was used for the manufacture of the 12 inch × 16 inch Crankshaft Bearing fitted to this 900 ton press by Rubery Owen & Co. Ltd. Alzen 305 was chosen for its great wear resisting qualities and for its great saving in cost and weight. Alzen 305 is eminently suitable for most Heavy Duty Bearing Applications and is supplied in the following forms :—Ingot, chill cast bars, cored and solid, in approx. 2 ft. lengths, sand castings, shell moulded castings, gravity die castings, pressure die castings, fully machined bushes and bearings.

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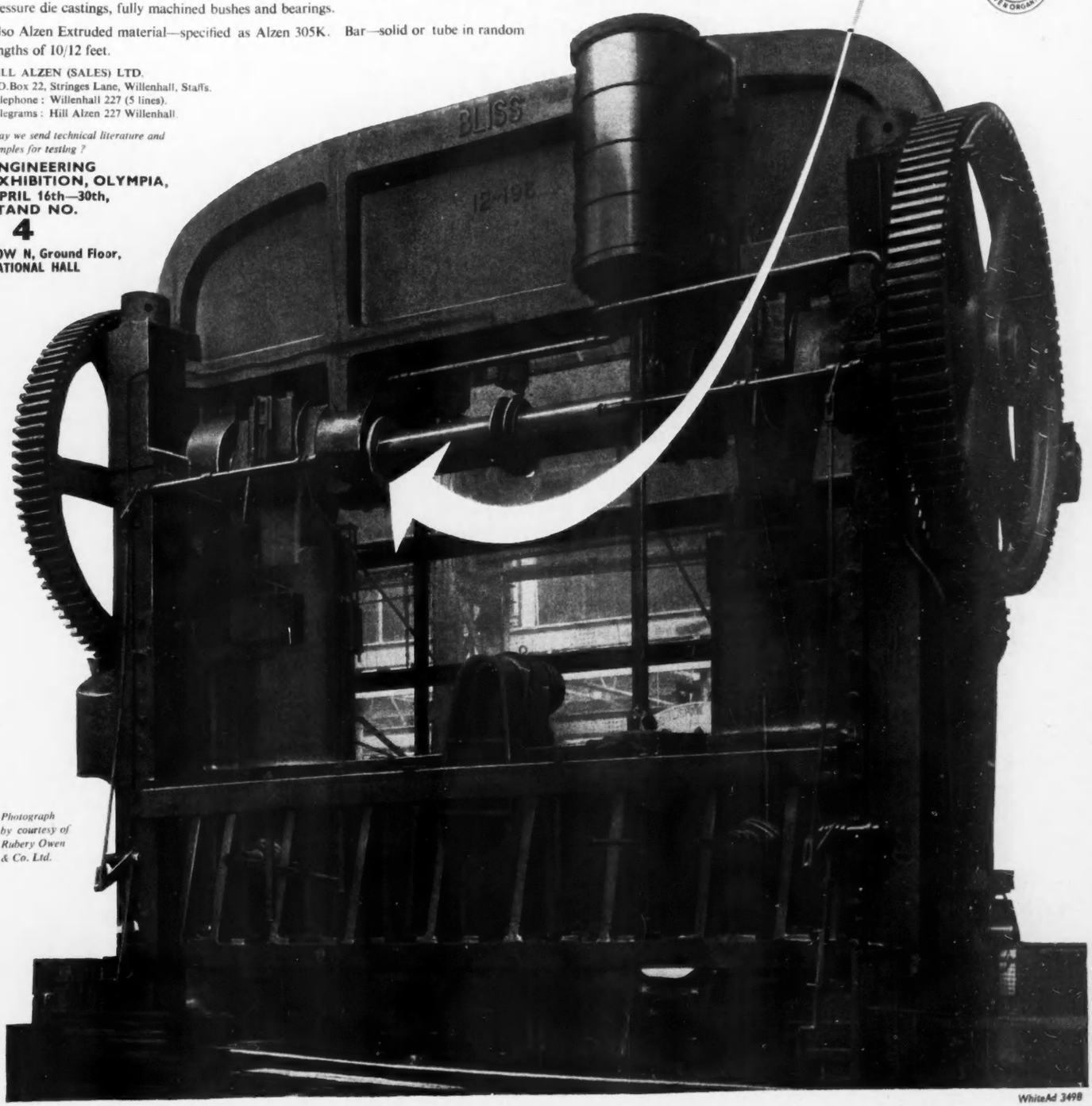

Photograph by courtesy of Rubery Owen & Co. Ltd.

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The latest large contract to go to John Howard & Co. Ltd. is the substructure of the new Forth Road Bridge.

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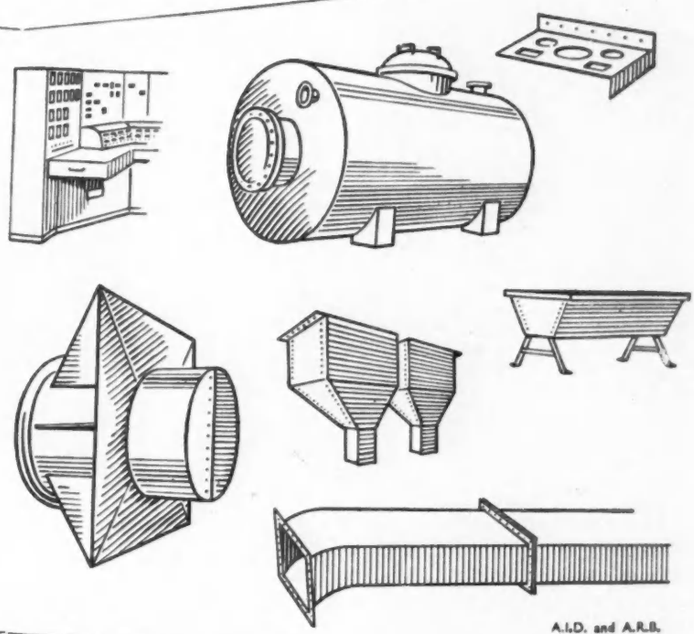

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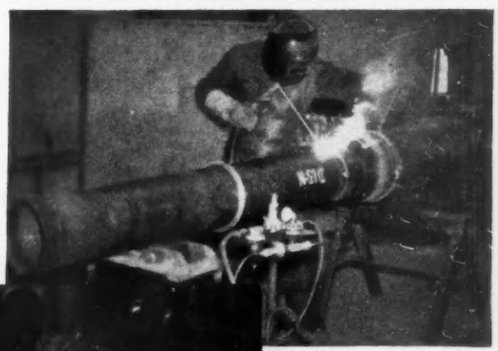
POWER STATION

The Unit Superheater and Pipe Co. Ltd., following initial contracts for reactor charge tubes for Calder Hall and Chapelcross power stations, has been entrusted by Whessoe Limited, member company of the Nuclear Power Plant Co., to produce the charge/discharge and control rod stand pipes for Bradwell Power Station.

'Unit' has laid down a production line capable of achieving the precision assembly and high standard of welding to manufacture these tubes to the close tolerances required. The photographs show stages in welding using low hydrogen electrodes throughout. All welds are ground flush externally and the bores dressed smooth. In accordance with Lloyds' requirements over 6,000 films will be needed to cover the radiographic examination of the welds.



WELDING

DRESSING

RADIOGRAPHY

UNIT

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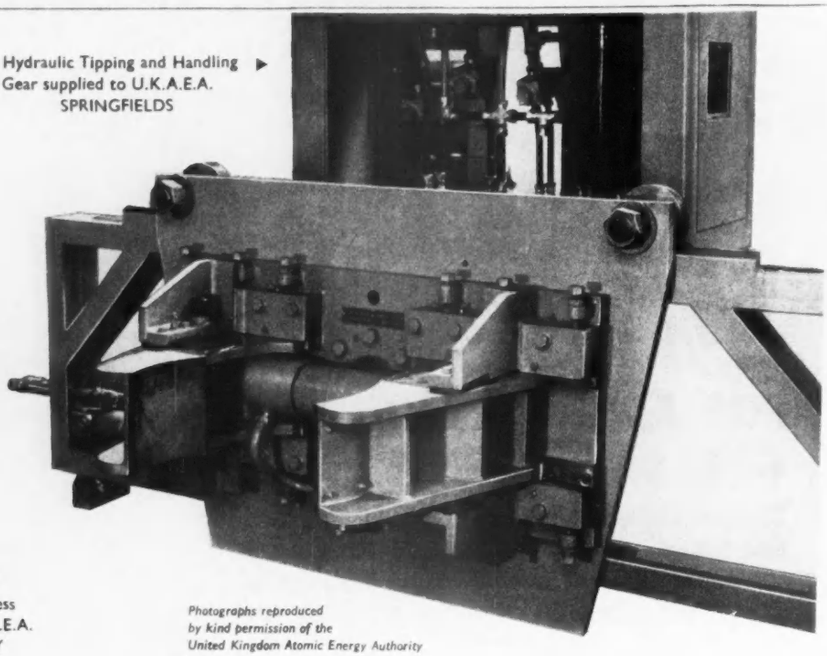
Unit Works, Swansea. Telephone: Swansea 54091 (6 lines). Telegrams: 'Superunits', Swansea. Telex: 48-208

SPECIAL PURPOSE EQUIPMENT SUPPLIED TO U.K.A.E.A.

Hydraulic Tipping and Handling Gear supplied to U.K.A.E.A. SPRINGFIELDS ▶



◀ 50 tons Hydraulic Double Acting Press supplied to U.K.A.E.A. DOUNREAY

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We will be pleased to quote for any Special Purpose Machinery

ENTWISLE & GASS LTD.

ASSOCIATED WITH THE PLANTERS ENGINEERING CO., LTD., LONDON

NELSON STREET, BOLTON *Telephone: No. 5967/8*

Established 1852

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at reasonable prices should contact The Sales Manager, John Swain & Son Ltd.

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Designing, plate-making and printing are all carried out under one roof, providing continuity throughout the production.

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TEAR HERE

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Please send specimens of letterpress/offset-litho.

Name_____

Messrs._____

Address_____

TEAR HERE

Please complete the form and send it to—

The Sales Manager

JOHN SWAIN & SON LTD

Designers and Colour Printers

89-92 Shoe Lane, London, E.C.4 · Tel: CITy 3871

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Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565

PUBLIC APPOINTMENTS

FEDERAL MINISTRY OF EDUCATION

RHODESIA AND NYASALAND

APPOINTMENTS

The Federal Ministry of Education of Rhodesia and Nyasaland invites applications for the following posts :

PRINCIPAL,
BULAWAYO TECHNICAL COLLEGE

Applicants should possess a good University Degree in Engineering and/or Corporate Membership of a Professional Institution and should have had experience of Teaching and organisation in Technical Colleges. The successful applicant will assume duty at some mutually agreed date in the middle of 1959.

Salary Scale : £2000 by £50 to £2050 by £100 to £2350.

SENIOR LECTURER

SENIOR LECTURER IN ELECTRICAL ENGINEERING, SALISBURY POLYTECHNIC

The successful applicant will be required to lecture in the electrical subjects of the examinations of the Institution of Electrical Engineers, London, up to and including Advanced Electrical Engineering, Part III, and any two specialised subjects at this level. Ability to lecture in Mathematics and Physics at Joint Part I level of the Engineering Institutions, London, will be an advantage ; some lecturing at a lower level may occasionally be required.

A University Degree and Corporate Membership of the Institution of Electrical Engineers, London, are essential.

Salary Scale : £1550 by £50 to £1900.

LECTURERS

LECTURER IN CIVIL ENGINEERING, TECHNICAL COLLEGE, BULAWAYO

Applicants should be Civil Engineers with a University Degree or its equivalent. They must be prepared to conduct classes for apprentices and for student engineers up to the level of the subjects of Group A of the Part II examination of the Institution of Civil Engineers, London.

LECTURER IN MECHANICAL ENGINEERING, TECHNICAL COLLEGE, BULAWAYO

Applicants should be Mechanical Engineers with a University Degree or its equivalent. They will be required to teach Mechanical Engineering, including Strength of Materials, Machine Design and Theory of Machines up to the level of Higher National.

LECTURER IN ENGINEERING SUBJECTS, TECHNICAL COLLEGE, BULAWAYO

Applicants should be Graduates or the equivalent and should be prepared to teach Machine Drawing, Heat Engines, Engineering Science, &c.

LECTURER IN MATHEMATICS AND PHYSICS, TECHNICAL COLLEGE, BULAWAYO

Applicants should have a good Honours Degree and will be required to teach Mathematics and Physics to the equivalent of G.C.E. "A" level.

Salary Scale for all Lecturers posts : £1300 by £50 to £1750.

One increment on the scale is allowed for each year of previous recognised experience as a Lecturer up to a maximum of six years.

NOTES ON TERMS OF SERVICE OF ALL POSTS ADVERTISED ABOVE

Service is permanent and pensionable subject to two years' probation. Passages to the Federation of those appointed are paid by the Government and half the cost of the passages of their families. Loan assistance is available towards that part of the cost of family passages which has to be paid by the applicant. Generous vacation leave is granted at regular intervals and once in every three years the return fares of the officer and his family are paid to any place in Africa not further from the Federation than Cape Town.

Facilities for the education of children up to the equivalent of G.C.E. "A" level are excellent in both Bulawayo and Salisbury. The level of taxation is relatively low.

It is desired to make appointments to all the posts advertised above as early as possible.

Closing date for applications : March 7th, 1959.

Further details and application forms may be obtained from : The Secretary (R), Rhodesia House, 429, Strand, London, W.C.2. E9945

PUBLIC APPOINTMENTS

KUMASI COLLEGE OF TECHNOLOGY

(Principal : W. E. DUNCANSON, Ph.D., D.Sc., F.Inst.P., A.M.I.E.E.)

SCHOOL OF ENGINEERING

LECTURERS

Applications are invited for the following :

(a) SENIOR LECTURER IN SOIL MECHANICS.

(b) LECTURER IN HYDRAULICS AND RELATED SUBJECTS.

(c) SENIOR LECTURER and LECTURERS IN MECHANICAL ENGINEERING.

Applicants should have a degree and/or corporate membership of a Senior engineering institution ; be capable of teaching for degree and institutions' examinations, and should state subjects qualified to teach. Industrial, research or teaching experience essential.

Appointment on contract for 5 years or on pension or the College will be prepared to take over and maintain employers' contributions to former F.S.S.U. policies.

Contract salary scale : £2125 by £75 to £2425 p.a. (Senior Lecturer) £1281 5s. by £62 10s. to £2031 5s. p.a. (Lecturer), plus gratuity payable at end of contract at rate of £12 10s. for each month of satisfactory service. Pensionable and F.S.S.U. salary scale : £1580 by £60 to £1940 p.a. (Senior Lecturer), £925 by £50 to £1625 p.a. (Lecturer). Entry point according to qualifications.

Children's allowances to a maximum of three at rate of £50 p.a. per child up to 10 years and £100 p.a. per child over 10 years in full-time education up to 21 years. Annual leave with free return first-class passages for member of staff, his wife and up to three children under 17 years. Bungalows with basic furniture at moderate rental provided. Income tax low.

Applications (6 copies) giving age, qualifications, experience and the names of 3 referees should be sent to the Council for Overseas Colleges, 12, Lincoln's Inn Fields, London, W.C.2. Closing date : 13th March, 1959. E9941

UNIVERSITY OF QUEENSLAND, AUSTRALIA

READER OR SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above position. Applicants should have a Degree or Higher Degree in Engineering of a recognised University together with design experience in industry and teaching experience at University level in design subjects. The appointee will be required to take charge of the design side of the course, in which he would be assisted by other lecturers, dealing with Mechanical Engineering students at all levels and students of other engineering and allied subjects in earlier years of the course. An interest in research is desirable.

Salary : £A2560–£A2800 p.a. or £A2160–£A2510 p.a.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1, or from the Registrar, University of Queensland, Brisbane, Queensland, Australia.

Applications close, in Australia and London, on 10th April, 1959. E9947

AUSTRALIA—MONASH UNIVERSITY (MELBOURNE, VICTORIA)

CHAIR OF ENGINEERING

The Interim Council of Monash University, newly constituted University in Victoria, invites applications for the position of PROFESSOR OF ENGINEERING.

The salary will be £A3500 per annum with superannuation similar to F.S.S.U. in Great Britain.

The appointee will be required to commence duty as soon as possible after appointment.

Conditions of appointment may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square, London, W.C.1.

Applications close 31st March, 1959. E9948

PUBLIC APPOINTMENTS

NEW SOUTH WALES DEPARTMENT OF TECHNICAL EDUCATION

SCHOOL OF MECHANICAL ENGINEERING, SYDNEY TECHNICAL COLLEGE

SUPERVISOR

Applications are invited for appointment to the position of SUPERVISOR, School of Mechanical Engineering, Sydney Technical College.

Salary will be between £A2198 and £A2348 p.a., according to qualifications. Applicants must possess a Degree, Diploma or equivalent qualifications in Engineering. Training and previous employment should include practice and supervision in both a skilled trade and professional engineering. Will be responsible to the Principal, Sydney Technical College, for developing and supervising courses to train skilled craftsmen and technicians and preferably should have had teaching experience at trade, post trade and diploma level. Applicants should produce evidence of satisfactory leadership qualities and of successful organising and administrative ability.

First-class ship fare to Sydney of appointee and family will be paid.

Successful applicant will be eligible, subject to passing medical examination, to contribute to the New South Wales Superannuation Fund.

Four copies of applications (including the names of two referees) should reach the Agent General for New South Wales, 56, Strand, London, W.C.2, by the 9th March, 1959. E9971

ESSEX EDUCATION COMMITTEE

SOUTH-EAST ESSEX TECHNICAL COLLEGE, LONGBRIDGE ROAD, DAGENHAM

HEAD OF THE MECHANICAL AND PRODUCTION ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD OF THE MECHANICAL AND PRODUCTION ENGINEERING DEPARTMENT (Grade V). Candidates should have high academic qualifications together with teaching and industrial experience. The appointment will be effective from the earliest date possible.

Persons who applied in response to the earlier advertisements need not re-apply.

Salary : £1900 by £50 to £2050, plus London Allowance and the 5 per cent special addition.

Application forms and further details (stamped, addressed foolscap envelope) obtainable from the Chief Education Officer, County Offices, Chelmsford. Closing date, 7th March, 1959. E9905

WEST RIDING EDUCATION COMMITTEE

MORLEY GRAMMAR SCHOOL (660)

MASTER IN ENGINEERING

Required for May (or September) MASTER to teach ENGINEERING subjects. Graduate or equivalent qualification. Increments allowed for Industrial experience. Graded Post (allowance £75) with prospects of increase. Candidates prepared in Mechanical Science "O" Level and Geometrical and Engineering Drawing ("A" Level). Developing Department.

Applications to be forwarded to the Headmaster, The Grammar School, Morley. E9954

LOUGHBOROUGH COLLEGE OF TECHNOLOGY

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applicants should possess good academic qualifications and have had experience in automatic control, preferably involving pneumatic or hydraulic systems.

Salary scale : £1417 10s. by £52 10s. to £1627 10s., with superannuation.

Application forms and further particulars from the Registrar, quoting ref. 1/C. E9865

PUBLIC APPOINTMENTS

UNIVERSITY OF NEW SOUTH WALES

NEWCASTLE UNIVERSITY COLLEGE

ASSOCIATE PROFESSOR IN ENGINEERING

The University of New South Wales invites applications for appointment to the newly created position of ASSOCIATE PROFESSOR IN ENGINEERING at Newcastle University College.

Salary : £A2858 per annum.

Applicants should be of high academic standing and on appointment will act as Head of the Department of Engineering.

In the Department the major courses of study are Mechanical, Electrical and Civil Engineering, and the successful applicant will be expected to promote the development of the activities of the Department ; in academic matters he will work in association with the Dean of the Faculty of Engineering of the University.

Newcastle University College is administered by the Warden under the Vice-Chancellor and Council of the University of New South Wales.

The successful applicant will be eligible, subject to a satisfactory medical examination, to contribute to the State Superannuation Fund, providing a pension of £A1400 per annum.

Associate Professors are eligible for six months' study leave on full salary after three years of service or twelve months after six years of service.

Subject to the consent of the University, Associate Professors may engage in a limited amount of higher consultative work.

The University reserves the right to fill the position by invitation.

First-class ship fare to Sydney of appointee and family will be paid.

Four copies of applications and supporting documents (including the names of three referees) should be forwarded to the Agent-General for New South Wales, 56, Strand, London, W.C.2, and a copy forwarded by Air Mail, in an envelope marked "University Appointments," to the Bursar, Box 1, Post Office, Kensington, New South Wales, Australia, not later than 31st March, 1959. E9972

CITY OF BRADFORD WATER DEPARTMENT

APPOINTMENT OF SENIOR ENGINEERING ASSISTANTS

Applications are invited for two superannuable appointments : (a) ONE SENIOR ENGINEERING ASSISTANT, Grade A.P.T.V. (£1175–£1325) ; and (b) ONE SENIOR ENGINEERING ASSISTANT, Grade A.P.T.IV (£1025–£1175).

Candidates for these appointments must be Corporate Members of the Institution of Civil Engineers and should have a wide experience in water supply. They will be required for work in connection with the general maintenance of the water undertaking, and particularly in the design and construction of large aqueduct pipelines, bridges, culverts, rapid gravity filtration and sedimentation tanks extensions, reservoir construction works, distribution boosters, &c.

Applications, stating age, training, professional qualifications and experience, together with the names of two referees, must reach the undersigned by 7th March, 1959.

Canvassing will disqualify, and an applicant who is related to a member or a senior official of the Council must disclose the fact in his application.

W. H. LEATHEM,
Town Clerk.

Town Hall,
Bradford, 1. E9907

MINISTRY OF LABOUR AND NATIONAL SERVICE

MANCHESTER

ELECTRICAL INSPECTOR OF FACTORIES

Pensionable post in Manchester for man or woman at least 35 on 1st February, 1959, who has achieved Corporate Membership of I.E.E. and has several years' professional experience. Responsible experience in electricity supply undertakings or manufacturing works an advantage. Salary scale (men), £1340 (lower if under 37) to £2000. This is under review. Promotion prospects.—Write, Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S4938/59. Closing date 4th March, 1959. E9913

Classified Advts. continued on page 128

PUBLIC APPOINTMENTS

ROYAL CORPS OF NAVAL CONSTRUCTORS

SCHOOLS ENTRY

A COMPETITION for ENTRY into the ROYAL CORPS OF NAVAL CONSTRUCTORS will be held in July, 1959.

2. Accepted candidates will be established as Probationers in the Royal Corps of Naval Constructors and will undergo a two-year course of training at the R.N. Engineering College, Manadon, and in H.M. Dockyard, Devonport, followed by a three-year course at the R.N. College, Greenwich.

3. Candidates must be aged between 18 years and 19 years 6 months, inclusive, at 1st September, 1959.

4. Candidates with the General Certificate of Education will be required to have passed at Advanced Level in at least Pure Mathematics, Applied Mathematics, Physics and to produce evidence of General Education at Ordinary Level.

5. Candidates with the Scottish Leaving Certificate will be required to have higher grade passes in Science, Mathematics, at least two additional mathematical subjects, and at least lower grade passes in English, and a language other than English.

6. Candidates from schools in Northern Ireland will be required to produce a certificate from the Ministry of Education in Northern Ireland showing a comparable standard to that above.

7. Applications will be considered from candidates who sit these examinations in 1959.

8. The work of the R.C.N.C. covers all aspects of design, construction and repair to H.M. Ships. Members undertake to serve wherever required at Admiralty headquarters, Outports in the United Kingdom and at Royal Dockyards at home and abroad. The present head of the R.C.N.C. is the Principal Technical Adviser to the Board of Admiralty.

9. The starting pay of a probationer at age 18 will be £527. A deduction of £75 is made when living in at the R.N. Engineering College, Manadon, or at the R.N. College, Greenwich. The successful probationer can expect an appointment as Assistant Constructor at age 23 or 24, with a starting salary of not less than £880 and £910 respectively. Promotion to Constructor normally takes place at about age 30, with a salary which may be expected to be not less than £1465, rising in nine years to not less than £2100. Promotion to higher ranks is by selection.

10. Full particulars may be obtained from the Secretary of the Admiralty, Civil Establishments Branch 11 (88), Empire Hotel, Bath, quoting reference number 5914, to whom final application must be submitted by 15th June, 1959. E9808

RUBBER RESEARCH INSTITUTE OF MALAYA

RESIDENT ENGINEER

The Rubber Research Institute of Malaya requires the services of a RESIDENT ENGINEER at the Rubber Research Institute Experiment Station, Sungei Buloh, Selangor. Duties will include supervision of work requiring engineering knowledge and practical experience in the maintenance of (i) water supply, including filtration plant and pumping equipment ; (ii) sanitation system with septic tank installations ; (iii) electricity supply and internal distribution from a mains supply at 400 volts ; (iv) all machinery in general use in the factory, including rubber sheeting and creping machinery, centrifuges, drying houses and packing equipment ; (v) agricultural mechanical equipment and vehicles, and (vi) general supervision of maintenance of all estate buildings. The emoluments (including standard allowances) of the appointment will be within the range $1320 by $40 to $2085 in Malayan currency per month = £1848 by £56 to £2919 per annum.

An officer who is not domiciled in Malaya is provided with rent-free quarters and is paid an additional allowance towards children's education.

Application forms and further information concerning conditions of appointment may be obtained from the Secretary, London Advisory Committee for Rubber Research, Commonwealth Institute, Imperial Institute Road, London, S.W.7.

Closing date for receipt of applications is 15th March, 1959.

February, 1959. E9968

MIDDLESEX COUNTY COUNCIL

COUNTY ARCHITECT'S DEPARTMENT

HEATING ENGINEERING ASSISTANTS

HEATING ENGINEERING ASSISTANTS (a) APT. IV £1055–£1205 p.a. (b) APT III £875–£1055 p.a. Must have good experience in design of heating and ventilating installations and be competent draughtsmen for preparation of contract drawings and specifications, &c.

JUNIOR ENGINEERING ASSISTANT APT. I, £605–£755 p.a. (if 26 or over). Some experience in preparation of plans and specifications for contracts for wiring, &c., of buildings.

Commencing salaries according to qualifications and experience. Prescribed conditions.—Application forms from County Architect, 1, Queen Anne's Gate Buildings, Dartmouth Street, S.W.1, returnable by 4th March. (Quote Z160 E.) E9933

MINISTRY OF SUPPLY

WEST FREUGH, STRANRAER, WIGTOWNSHIRE

TECHNICIAN

Ministry of Supply require TECHNICIAN at West Freugh, Stranraer, Wigtownshire, primarily to supervise and organise preparation of aircraft for trials work, including co-ordination with the Armaments Section and Trials Controller. Duties also involve supervision of small engineering workshop. Qualifications : recognised engineering apprenticeship ; possession of O.N.C., appropriate C. and G. Final Certificates or equivalent qualification desirable. Experience of aircraft maintenance and inspection essential. Salary : £820 (age 30) to £974 p.a.—Application forms from Ministry of Labour and National Service (P.E.367), Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. E9962

PUBLIC APPOINTMENTS

SOUTH WEST METROPOLITAN REGIONAL HOSPITAL BOARD

REGIONAL ENGINEER'S DEPARTMENT

ASSISTANTS

Applications are invited for the following appointments on the permanent staff of the Board generally in accordance with the Whitley Council conditions of service.

SENIOR ASSISTANT ENGINEER (MECHANICAL) : The commencing salary will be at the minimum of the scale £1010 by £30 (5) by £35 (1) to £1195 p.a., plus London Weighting allowance of £50 p.a. Applicants should be Corporate Members of the Institution of Mechanical Engineers and should be experienced in the preparation of specifications, drawings and estimates for large engineering installations in hospitals and large public buildings.

ASSISTANT ENGINEER (MECHANICAL) : Applicants should have served a recognised engineering apprenticeship and must be Graduate members of the Institution of Mechanical Engineers, and have passed "A" and "B" of the Associate Membership examination, or hold exempting qualifications. Corporate membership of the Institution of Heating and Ventilating Engineers will qualify. Sound experience of design of mechanical services of large buildings required. Drawing Office and Estimating experience an advantage.

Salary (Assistant Engineers) : £700 by £25 (3) by £30 (1) by £35 (6) to £1015 p.a., plus London Weighting allowance of £20–£50 p.a. The commencing salary may be fixed above the minimum of the scale for relevant practical experience.

Applications for the Senior Appointment stating age, qualifications, experience, present appointment and salary, together with the names and addresses of three referees should be sent to the undersigned at 40, Eastbourne Terrace, London, W.2, by not later than 2nd March.

Application forms for the other appointment may be obtained from the same address and must be returned completed by not later than 2nd March.

E. G. BRAITHWAITE,
Secretary.

E9969

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Nava Scientific Service requires SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS for establishments in London area, Baldock, Portsmouth, Portland, Poole and Rosyth. Main requirements are for PHYSICISTS, MECHANICAL ENGINEERS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist : Mathematician : for applied research of basic nature and stability of underwater vehicles ; knowledge of theoretical hydrodynamics and theory of control systems an advantage ; London area. Mechanical Engineer : with sound knowledge of basic principles of thermo and fluid dynamics, to carry out research programme in a particular field of applied hydrodynamics ; experience in modern methods of design and research on axial-flow compressors, turbines or pumps an advantage ; London area. Mechanical Engineers : for design and development of underwater devices ; Portland area. Physical Chemist : with specialised knowledge of rubber technology ; Poole area. Chemists : Physical and Inorganic ; Poole, Baldock and London areas. Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent high professional attainments. S.S.O.s must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) : S.S.O., £1190–£1410 ; S.O., £635–£1110 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1 (quote A.500/8A). E9615

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

RISLEY, WARRINGTON, LANCASHIRE

TRAINING OFFICER

TRAINING OFFICER required by the United Kingdom Atomic Energy Authority, Industrial Group Headquarters, in the Personnel and Administration Branch at Risley, Warrington, Lancashire, to assist in the organisation of training and education schemes for engineers, graduate apprentices and junior engineering staff.

Applicants must be qualified engineers, with Corporate Membership of a senior engineering institution, or equivalent, and should have had experience in educational administration, training in industry, or in teaching or lecturing. The work calls for a good personality with an ability to assess the training and educational needs of junior staff.

Salary between £1300 and £1740, according to qualifications and experience.

Contributory superannuation. Staff housing scheme.

Send postcard for application form, quoting reference 2927/J1, to Recruitment Officer at above address.

Closing date : 23rd February, 1959. E9917

DOVER HARBOUR BOARD

ASSISTANT CIVIL ENGINEER

Applications are invited for the post of ASSISTANT CIVIL ENGINEER of age 28 to 32 years.

Applicants must hold a Civil Engineering Degree or have passed the Graduate or Associate Membership examination of the Institution of Civil Engineers. Previous knowledge of dock and harbour work an advantage ; salary according to qualification, age and experience.

Applications, giving particulars of age, training and qualification, together with names of three persons to whom reference may be made, should be sent to Dover Harbour Board, Harbour House, Dover, Kent. E9966

PUBLIC APPOINTMENTS

ATOMIC ENERGY RESEARCH ESTABLISHMENT

HARWELL

TECHNICAL OFFICERS, with apprenticeship or equivalent training and a good engineering background are required to assist in the preparation of detailed estimates of cost of mechanical and/or electrical engineering components for a large capital project. The posts will involve liaison with scientists, engineers and finance officers. Adaptability and engineering "know how" are more important than estimating experience. Salary £875–£1050 ; housing and superannuation schemes.

Please send a postcard to the Group Recruitment Officer (1353/25), U.K.A.E.A., Harwell, Berks, for details.

E9911

PUBLIC APPOINTMENTS

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY GLASGOW

(In affiliation with the University)

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the above lectureship from Honours degree candidates with interest in Theory of Machines and, if possible, experience in Mechanical Design and Strength of Materials. Excellent research facilities are available. Salary on the scale £900–£1650 with F.S.S.U. and family allowances.—Application forms are obtainable from the Secretary.

E9953

MINISTRY OF WORKS

REQUIRES

ENGINEERING DRAUGHTSMEN IN THE FOLLOWING CATEGORIES

HEATING AND VENTILATING

Design of all types of installations, including air conditioning.

ELECTRICAL

Design of lighting, power and special type installation, and site distribution schemes.

STRUCTURAL

Design and detailing of reinforced concrete or structural steelwork.

For employment in LONDON and PROVINCES on major site developments and all classes of PUBLIC and INDUSTRIAL BUILDING.

GENERAL CONDITIONS

Salary range £550 (age 21) to £870 p.a. in London (slightly less elsewhere). Starting point according to age, qualifications and experience ; 5-day week ; 3½ weeks' annual leave initially, and concessions for higher technical training in approved cases. Prospects of promotion to posts with salaries of £1015 p.a. and above. Opportunities for permanent posts leading to pensions, non-contributory.

QUALIFICATIONS

Technical education to O.N.C. or equivalent standard.

APPLICATIONS

State age, experience, training and qualifications, to : The Chief Engineer, Ministry of Works, Room 435, Abell House, John Islip Street, LONDON, S.W.1.

Interviews at Regional Offices when possible.

E9500

ENGINEERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

2170/25 ENGINEER (MAIN GRADE)

To be in general charge of a group of technical officers who perform the following functions :—

(*a*) Inspection of coded items on receipt and during storage.

(*b*) Preparation and maintenance of specifications for coded items.

(*c*) Preparation of catalogues of coded items, including joint catalogues where appropriate in conjunction with A.E.R.E., Harwell.

(*d*) Intergroup negotiations on standardisation of common items.

(*e*) Technical assistance to Contracts Branch and to the Site generally in connection with procurement of materials.

These functions cover the fields of mechanical and electrical/electronic engineering and laboratory equipment and chemicals.

It is expected that the occupant of this post will have to undertake personally much of the work on standardisation which will involve close contact with various Superintendencies and with other Groups.

2171/25 ENGINEER (BASIC GRADE)

To take charge, under an Engineer II, of the mechanical engineering and laboratory supplies section.

These duties will also involve close contact with other Superintendencies and other Groups on standardisation and the preparation of catalogues.

QUALIFICATIONS.

A recognised engineering apprenticeship or equivalent training and Corporate Membership of a Senior Engineering Institution are required, with some experience in standardisation of engineering components and stores procedures.

It is intended that the successful applicants should perform these duties for a term of 18 months, after which they will be transferred to other engineering duties and be replaced by a further two engineers serving for a similar period.

SALARY :—Eng. II £1,345—£1,800

Eng. III £845 (at age 25)—£1,150 (at age 34 or over)—£1,315

Contributory Superannuation Scheme. A house or, alternatively, substantial assistance with house purchase, will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer at above address. Please quote appropriate reference number.

E9937

PUBLIC APPOINTMENTS

AUTOMATIC FIRING EQUIPMENT

Applications are invited for posts as RESEARCH SCIENTISTS for work of national importance on the development of fully automatic firing equipment. The appointment offers opportunities for gaining valuable experience in modern research techniques, automation and instrumentation in well-equipped laboratories at a well-known Research Station in pleasant surroundings. There are opportunities for publishing the results of successful work. Candidates should have a degree (or equivalent) in Physics or Fuel Technology, and previous research experience would be an advantage. Starting salary in the range £750–£1100, and good prospects of advancement for graduates with research ability. 5-day week and congenial working conditions. Superannuation and Grading Schemes.—Apply in writing to Assistant Secretary, Ref. F.4, B.C.U.R.A., Randalls Road, Leatherhead, Surrey.

E9931

TENDERS

GOVERNMENT OF HONG KONG

LAN TAO SCHEME

SHEK PIK DAM

The Government of Hong Kong invite TENDERS from Contractors with suitable experience for the CONSTRUCTION of the SHEK PIK DAM.

The main items of the work are :

(a) a dam about 2800ft. long and 176ft. maximum height, constructed of about 5,000,000 cubic yards of rolled fill.

(b) a concrete overflow bellmouth spillway.

(c) a 17ft. diameter diversion tunnel about 1700ft. long.

Contract documents can be inspected at the offices of the undersigned and can be obtained from them on the payment of Twenty-five pounds, on or after the 27th February, 1959—the deposit to be refunded on receipt of a bona fide tender.

BINNIE, DEACON & GOURLEY,
MM.I.C.E.,

Artillery House,
Artillery Row, Westminster,
London, S.W.1. E9963

BOOKS and PUBLICATIONS

PITMAN

TECHNICAL BOOKS

STEAM TURBINE THEORY AND PRACTICE

By William J. Kearton, D.Eng., etc. 7th Edition. Here is a new and up-to-date edition of this standard work. Completely revised throughout and with an extra 230 pages, this new edition is an essential work for all engineering students and draughtsmen. 57s. 6d. net.

THE HEAT-TREATMENT OF STEEL

By Edwin Gregory. Ph.D., etc., and Eric N. Simons. New and up-to-date 2nd Edition. Covers every phase of the subject from principles to practice. It is very easy to read and explains what has to be done to different steels and why it is necessary. Recent developments are dealt with. 35s. net.

METAL RECTIFIER ENGINEERING

By E. A. Richards, M.B.E., A.C.G.I., etc. Discusses in detail the principles underlying the operations of metal rectifiers. It forms an essential book for engineers wishing to select the right type of rectifier for a particular job, and avoid the disappointments that can arise from incorrect working conditions. 37s. 6d. net.

THE PUMP USERS' HANDBOOK

Compiled on behalf of The British Pump Manufacturers' Association by Herbert Addison, O.B.E., M.Sc., etc. Sponsored by members of the B.P.M.A., this new handbook offers direct help and guidance to owners and users of pumping plant. Covers installation, maintenance, performance, cavitation, pressure-surges, etc. 30s. net.

From all Booksellers

Parker St., Kingsway, London, WC2

JUST PUBLISHED —

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KEMPE'S

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TENDERS

ADMIRALTY

N.A.T.O. BOOM DEFENCE DEPOT AND JETTY (COMMON INFRASTRUCTURE SLICE VI)

Final notice is hereby given that bids will be invited on or about the 16th April, 1959, for the INSTALLATION of the ELECTRICAL SUPPLY and DISTRIBUTION SYSTEM for a Depot and Jetty to be built on the West Coast of Ayrshire, Scotland. The electrical work, for which detailed specifications and drawings will be made available, will be undertaken as one contract, and will be carried out as a sub-contract within the main contract for the construction of the depot.

2. The approximate cost of the contract will be £20,000 and will comprise the following :—

(a) Internal electrical installation in various buildings, including an office, workshop and store building.

(b) External cabling within the depot, excluding the Electricity Board's cables.

(c) External lighting of the depot.

(d) Jetty lighting, including navigation lights.

(e) Terminations for shore/ship supplies.

3. It should be noted that the importation of labour from sources outside the United Kingdom may be subject to restriction and that permission could in any case be granted only on an undertaking that the contractors would pay rates of wages and observe hours and conditions of labour not less favourable than those established for United Kingdom labour for the trade or industry in the same area.

4. Firms wishing to be invited to bid on the basis of sub-contractor to a main contractor must formally notify their desire to tender by application to the address given in paragraph 6 below not later than 19th March, 1959.

5. Within one week of the closing date for receipt of applications to bid, firms wishing to be invited must forward the following information :—

(a) Statement of financial resources and evidence of financial stability.

(b) Details of recent major contracts completed for work of a comparable nature, including an indication of the value of each.

6. Enquiries regarding bidding should be addressed to The Civil Engineer-in-Chief, Admiralty, Chamberlain Way, Pinner, Middlesex, England, quoting reference C.E. in C./INFRA/4 (Sub-Contract Electrical Installation).

Admiralty, S.W.1. E9922

HALSTEAD RURAL DISTRICT COUNCIL

HEDINGHAMS AND GREAT YELDHAM DRAINAGE

CONTRACT NO. 9

TO MANUFACTURERS OF CENTRIFUGAL PUMPING PLANT

TENDERS are invited for the MANUFACTURE, SUPPLY and ERECTION of 7 SETS of VERTICAL UNCHOKEABLE SEWAGE PUMPS and ANCILLARY EQUIPMENT. The plant will be contained in two pumping stations. Two pumps shall be capable of a duty of 150 gallons per minute against a total head of 34ft.; two pumps for a duty of 250 gallons per minute against 30ft. total head ; two pumps for a duty of 375 gallons per minute against 30ft. total head ; and one pump for a duty of 325 gallons per minute against 37ft. total head, all in accordance with the specification and drawings prepared by the Engineers, Messrs. John Taylor and Sons, Artillery House, Artillery Row, Victoria Street, Westminster, S.W.1.

Copies of the specification and drawings may be obtained from the offices of the Engineers upon payment of £5 (cheque only, drawn favour of the in above Council), which will be returned on receipt of a bona-fide Tender not subsequently withdrawn. The contract documents may be inspected at the offices of the Engineers or the Council Offices.

Tenders, in plain, sealed envelopes, endorsed "Pumping Plant—Contract No. 9," are to be delivered to the undersigned on or before noon on the 11th March, 1959.

(Signed) H. E. P. STOKES,
Clerk of the Council.

Rural Council Offices,
Mount Hill,
Halstead,
Essex. E9850

BRISTOL AVON RIVER BOARD

CONTRACT NO. 186

The Bristol Avon River Board invites TENDERS for CIVIL ENGINEERING WORKS at Avon Mill, near Chippenham, Wilts.

The work comprises the demolition of part of the existing structure, the driving of steel sheet piling, excavation, concrete sluiceway and chambers, R.C. farm bridge, &c., in connection with the installation of a 30ft. by 8ft. automatic radial sluice gate.

Applications for copies of the specification, bill of quantities, conditions of contract and contract drawings should be made to the undersigned.

Tenders, duly sealed and endorsed "Contract No. 186," must be delivered to the Clerk of the Bristol Avon River Board at 18, Bennett Street, Bath, not later than noon on Tuesday, 17th March, 1959.

F. GREENHALGH,
Engineer to the Board.

18, Bennett Street,
Bath,
February, 1959. E9924

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

TENDERS

INDIA STORE DEPARTMENT

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the supply of :

SNAP GAUGES, PLUG GAUGES, MICROMETERS, VERNIER CALIPERS, HIGHER GAUGES, BORE DEPTH GAUGES and other MEASURING TOOLS and INSTRUMENTS.

Please quote reference No. 18110/GNK/HAL.

The Tender forms with schedules and Specifications which are returnable on Thursday, 19th March, 1959, may be obtained from the above office (C.D.N. Branch) on payment of a fee (which is not refundable) of ten shillings for each tender.—Applications for tenders should clearly state the reference number of the tenders required. E9944

EDUCATIONAL

UNIVERSITY OF LONDON

A COURSE of THREE LECTURES, entitled "Physical Behaviour of Concrete and its Influence on Structural Strength," (i) "The Stress-Strain Line and the Influence of Time," (ii) "Physical Causes of Observed Behaviour," (iii) "Application to a New Theory of Bending," will be delivered by Professor H. Rüsch (Technische Hochschule, Munich), at 5.30 p.m. on 3rd, 5th and 6th March, at University of London, Senate House, W.C.1. ADMISSION FREE, WITHOUT TICKET.

JAMES HENDERSON
Academic Registrar.

E9923 E

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

BURSARIES IN CONCRETE TECHNOLOGY

BURSARIES of £460–£760, according to experience, are available for Session 1959–60. Candidates must hold a Degree in Engineering and have good knowledge of theory of structures.—Full information from the Registrar, Imperial College, London, S.W.7. Closing date June 1st, 1959. E9916 E

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

DEPARTMENT OF MATHEMATICS

The next SANDWICH COURSE in Applicable Mathematics (of four years' duration) will begin in September, 1959. The course is recognised for the award of the Diploma in Technology. State Scholarships, Technical State Scholarships, and Local Education Authority awards may be held by students attending this course.

Enquiries are invited from students and also from industrial organisations, schools and further education establishments which may wish to recommend students for the course.

N. M. H. LIGHTFOOT,
M.A., F.R.S.E.,
Principal.

E9915 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E., A.M.I.Chem.E., A.M.I.M.I., A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHTS LANE, LONDON, W.8.
E102 E

AUTOMATION.—AUTHORITATIVE COURSES are now available in Digital and Analogue Computer Technology, Applied Electronics, Data Processing and Instrumentation up to professional level by home study. Individual enrolment or industrial group scheme enrolments accepted. Syllabuses and prospectus sent on request.—Write (Dept. S.E.8), E.M.I. Institute School of Electronics, College House, Kensington, London, W.8. E145 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A YOUNG ENGINEER'S OPPORTUNITY. World's leading Automation Company seeks O.N.C. (Electrical) student, or similar, for important work on heating systems. Essential qualifications : between 20 and 25 years : above average intelligence ; enthusiastic personality ; ambition to become a sales or contracts engineer. The successful candidate will help in preparation of wiring diagrams, and generally assist the senior engineers. Good starting salary. Canteen. Social club. Generous insurance and superannuation scheme. New building with all modern amenities.—Write now, quoting "Reference REA" to HONEYWELL CONTROLS, LTD., Ruislip Road East, Greenford, Middlesex. E9935 A

Classified Advts. continued on page 130

SITUATIONS VACANT

A FIRST-CLASS, EXPERIENCED AND QUALIFIED ENGINEER (Mechanical, Aeronautical and General Engineering background), with ability to think freely, clearly and imaginatively, required by consultants for developments in new industrial field.—Norris Brothers, Limited, 62, Church Road, Burgess Hill. E9959 A

AN ASSISTANT POWER STATIONS SUPERINTENDENT

is required by Texaco Trinidad, Incorporated, for two power stations with a combined installed capacity of 23,000kW and associated steam, compressed air and water-treating plant, at their oil refinery in the West Indies.

Applicants should preferably be A.M.I.Mech.E., aged 30–35 years, and have at least 7 years' experience of the operation of modern turbo-generators and gas and oil-fired boilers.

Salary will be not less than £1400 per annum, and subsidised accommodation and schooling for children are available.

Please write with brief particulars to the

Personnel Officer,
TRINOIL (U.K.), LIMITED,
Trinidad House,
Old Burlington Street, London, W.1.

E9930 A

AN ELECTRICAL ENGINEER is required to undertake responsibility for electrical maintenance and installation and development work in a modern, highly mechanised factory producing seamless steel tubing. The electrical equipment of this plant covers a wide range of A.C. and D.C. drives, up to a capacity of 2000 h.p. The successful applicant would be expected to assume supervisory control of existing electrical staff. Candidates, preferably in the age range 26–30, should hold at least a Higher National Certificate and have had appropriate experience in a similar capacity.—Applications, giving full details of education, previous positions held, in chronological order and salary required, should be addressed to the Works Director, TUBES, LIMITED, Desford Lane, Kirby Muxloe, Leics. E9955 A

AN EXPANDING WEST END BUSINESS WANTS SENIOR ENGINEER with practical knowledge of Tape Recording Amplifiers, to help develop new project. Apply.—BOX No. E2292, "The Engineer." A

ASSISTANT TO LONDON AREA MANAGER to take charge of busy London Sales Office for North Country Engineers. Must be experienced in commercial practice, office organisation and methods. Engineering experience desirable but not essential. Apply giving full details of experience and salary.—BOX No. E9964 "The Engineer." A

BRITISH RAILWAYS (SOUTHERN REGION) require an ELECTRICAL ENGINEERING TECHNICAL ASSISTANT in the MANCHESTER AREA for the inspection and testing of electric rolling stock and power supply equipment at Contractors' Works. Applicants should have had a sound technical training and have reached a standard of not less than that of the Higher National Certificate in Electrical Engineering. Manufacturing experience essential. Commencing salary £943 per annum rising to £985 after two years.—Applications in writing to be addressed to the Chief Mechanical and Electrical Engineer, British Railways (Southern Region), 15, St. Thomas' Street, London Bridge, S.E.1. E9939 A

CANADIAN COMPANY REPRESENTING A GROUP OF BRITISH ENGINEERING MANUFACTURERS seek a SALES ESTIMATOR AND CORRESPONDENT for their Montreal office. Preference is for a single man, 26 to 30 age group, who has H.N.C. standard or equivalent, has served a recognised apprenticeship in mechanical or electrical engineering and who has some experience in handling overseas correspondence of a manufacturing firm. Opportunity will be given to study the various products at the United Kingdom manufacturers' work before leaving for Canada.—BOX No. E2308, "The Engineer." A

DRAUGHTSMEN, SENIOR DESIGNERS, with a thorough knowledge of mechanical handling, urgently required near Liverpool. Generous salaries to experienced men. Write in confidence, stating qualifications and experience.—BOX No. E9900, "The Engineer." A

ENGINEER with knowledge of Rubber Machinery, both use and design, preferably under 35, but not essential. Good prospects with expanding firm building Rubber Machinery in the South.—State age, experience, qualifications and salary required. —BOX No. E9942, "The Engineer." A

ENGINEERING SALES. — A TECHNICAL REPRESENTATIVE is required by leading manufacturers of power station and industrial water-tube boilers and associated steam engineering equipment. Age range : 35–50 years. Essential qualifications are an intimate knowledge of subject plus good technical qualifications and experience at the level indicated, also ability to present a convincing case for a first-class product.—Applications, with full details of previous experience and an indication of the salary required, should be addressed.—BOX No. E9876, "The Engineer." A

EXPERIENCED ENGINEERING DRAUGHTSMAN required at the Head Office of a well-known manufacturing company in the MIDLANDS. Layout experience of heavy process plant (fertilisers, chemicals, &c.) over a number of years essential.—Applicants must give details of experience and salaries earned to BOX TE.249, c/o 191, Gresham House, E.C.2. E9960 A

FULLY QUALIFIED ENGINEER, to be directly responsible to the Partners, required by medium-sized firm of Consulting Engineers in Westminster. Should have had varied civil and structural engineering experience including road and bridge works. Age 35–45.—BOX No. E2303, "The Engineer." A

FOUNDRY SALES REPRESENTATIVE REQUIRED for London and Home Counties. Applicants must be experienced in the sale of all grades of cast iron. Write, giving full details of experience, age, and salary required.—BOX No. E2309, "The Engineer." A

HEAD ESTIMATOR required after Easter by rapidly expanding welding and metal fabricators in Home Counties. Good salary with house to man with right experience. Applicants can only be considered who give in their own handwriting full details of career to date, including exact description of classes of work, present employer, and salary.—BOX No. E2307, "The Engineer." A

INSPECTOR/DIVER for harbour works at Whitby, to supervise driving of sheet piling and placing of concrete under water. Duration of contract 21 months.—Apply : Lewis and Duvivier, 122, Victoria Street, London, S.W.1. E2306 A

JUNIOR DETAIL/DESIGN DRAUGHTSMAN for Structural Steelworks. Pension Scheme (non-contributory). Small house could be made available for selected applicant.—Write, giving age, details of experience and salary required to Mr. H. Knott, Croggon and Co., Ltd., Poyle Steelworks, Colnbrook, Near Slough. E2310 A

LONDON FIRM IMPORTING CONTINENTAL WOODWORKING AND PLASTICS MACHINERY require young ENGINEER on sales side. He should have good general engineering knowledge and knowledge of German an advantage.—BOX No. E2302, "The Engineer." A

MOTORWINDER—Qualified. Mainly required for Stators of A.C. Motors, all sizes up to 10 h.p. for BERMUDA. Single man preferred. Apply stating experience, age, salary expected.—BOX No. E9926, "The Engineer." A

OPENING FOR A MAN to help on both technical and commercial sides of small individual firm of mechanical engineers in Yorkshire. Must be a live man who would attend to detail and someone used to working with the principal of a small firm. —State age, experience and present salary.—BOX No. E9561, "The Engineer." A

REQUIRED BY DIESEL ENGINE MANUFACTURERS, A SENIOR SALES ENGINEER with extensive experience and contacts in the heavy vehicle industry.—Applicants are requested to give precise details of their experience. A good salary will be paid to the right man.—BOX No. E9938, "The Engineer." A

RESIDENT ENGINEER for harbour works at Whitby, Yorks. Duration of contract 21 months. Applicants should be Chartered Civil Engineers with considerable experience of maritime works.—Apply : Lewis and Duvivier, 122, Victoria Street, London, S.W.1. E2305 A

SALES ENGINEER.—Nationally known manufacturing organisation in West of England, one of whose major activities is the manufacture of Industrial Equipment such as Ovens, Spraybooths, Rust-proofing Machines, Dust Collectors and Conveyors, require the services of a Sales Engineer. General experience in Heating and Ventilating is required with recent engineering sales experience in continuous paint finishing equipment. Please submit full details of experience, age, &c.—BOX No. E9950, "The Engineer." A

SENIOR INSTRUMENT ENGINEER

Leading Contractors to the Oil Refinery and Chemical Engineering industry would be pleased to receive applications from suitably qualified engineers who have a sound experience in the design of large scale control installations. This position offers excellent prospects and a commencing salary of at least £2500 p.a.

Please write full particulars which will be treated in the strictest confidence to Managing Director, BOX No. E9946, "The Engineer." A

TECHNICAL ASSISTANTS (PATENTS).—The Dunlop Patent Department, a central organisation of the company located in their Research Centre at Birmingham, desire to appoint one or two Chemists and an Engineer, all with adequate patent experience, to responsible positions, where they will handle British and foreign applications with minimum supervision. Also an Engineer without patent experience to be trained as a Patent Agent. Applications are invited, preferably from Graduates, giving, in confidence, brief details and salary expected. Usual five-day week, pension scheme, good prospects and working conditions.—Please reply, quoting reference J.M.162, to Personnel Manager, DUNLOP RESEARCH CENTRE, Erdington, Birmingham, 24. E9792 A

TUBE INVESTMENTS RESEARCH LABORATORIES, HINXTON HALL, CAMBRIDGE. GRADUATE required for basic studies of friction and wear. This post offers excellent opportunities for the man wishing to combine fundamental research with the technical problems in a large and diverse engineering organisation. Candidates should possess a degree in Physics or Engineering (or equivalent qualifications).—For further details and application form, write to the Secretary, quoting reference E.151. E9932 A

WEST MIDDLESEX FIRM REQUIRE EXPERIENCED PRODUCTION ENGINEER, with technical qualifications, to take charge of medium-sized machine shop and organise batch production of light engineering products. Contributory pension scheme in operation. Please give details of previous positions and state qualifications and salary required. —BOX No. E9961, "The Engineer." A

WORKS MANAGER, aged 35–40, for sheet metal works. Fifteen miles South of London employing 100. Knowledge modern methods of production and control essential. Write, stating age, salary required, previous experience.—BOX No. E9925, "The Engineer." A

AERO ENGINE DEVELOPMENT

Alvis, Limited, have a vacancy in their Aero Engine Development Department for an ENGINEER with either a Degree or H.N.C. to work on problems associated with engine design and development.

The selected candidate will ultimately be required to cover all technical aspects of the work, including the initiation of experimental schemes, and the analysis of test results. Previous experience of engine work is desirable, but not essential.

Applicants should write, giving full details of previous experience, age and salary required, to, :—

The Secretary,
Alvis, Ltd.,
Coventry.

E9957 A

THE BAHRAIN PETROLEUM COMPANY LIMITED GRADUATE METALLURGISTS & MECHANICAL ENGINEERS

are required in Bahrain's modern Oil Refinery for plant and corrosion inspection work. Applicants, under 35, should be familiar with API, ASME codes and have had a minimum of two years' experience in similar work or in the construction and maintenance of fired and unfired pressure vessels, the duties including inspection of vessels, exchangers, pumps, lines, valves, &c., to ensure safe operating condition and the recommending and developing of materials and methods of repair and corrosion control.

Salary would be in accordance with qualifications and experience but not less than £1332 per annum in addition to which free air conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided.—Apply in writing with full particulars to Caltex Services, Ltd., Caltex House, Knightsbridge Green, London, S.W.1, quoting "INS."

E9904 A

BUILDING INDUSTRY

SPECIALIST SUB-CONTRACT SUPERVISOR

A major firm of Building and Civil Engineering Contractors in Northern England require an experienced ENGINEER/SUPERVISOR for specialist sub-contracts. He will be the Liaison Officer between themselves as Main Contractors and the numerous sub-contractors carrying out the mechanical and industrial services on large projects.

Applicants should preferably be qualified, be good organisers and have considerable experience in design and installation contract work, using up-to-date methods of planning and progressing.

Good prospects and staff conditions, pension scheme and other benefits.

Apply Managing Director, BOX No. E9910, "The Engineer." A

C. A. NORGREN LTD.

and Associate Companies

have a position with excellent prospects open for a

QUALIFIED ENGINEER

Compressed Air Equipment is our business and our Company is a progressive one in a growing field.

We offer a salary according to qualifications for duties involving Experimental and Drawing-Office work, Customer Liaison and acting as Assistant to General Manager, Technical Manager and Product Engineer.

If you are aged 26–32 years, have an Engineering Degree and Workshop training, and consider you have a pleasing personality and executive ability, we should like to hear from you.

Please write in confidence giving full details of education and career to :

General Manager, C. A. NORGREN LTD.
SHIPSTON-ON-STOUR, WARWICKSHIRE.

E9934 A

INSTRUMENTATION ENGINEER

One of the Groups engaged in the construction of nuclear power stations requires an Instrumentation Engineer to be responsible for commissioning the complete instrumentation and for its maintenance during the initial power operation. The successful candidate should hold a University Degree or equivalent qualifications and have considerable experience of industrial plant instrumentation.

Please write, giving details of education, qualifications and experience, to BOX E4034 LPE, Romano House, 399/401, Strand, London, W.C.2.

E9940 A

THE NUCLEAR POWER PLANT COMPANY LIMITED

requires

ENGINEERS

to commission Nuclear Power Stations

Applicants should have had considerable operational experience of large Conventional Power Stations and be of either Charge Engineer or Assistant Charge Engineer status.

The Company operates a Contributory Pension Scheme and assistance with house purchase is given to married men.

Applications, stating age, qualifications and experience, should be addressed to :—

The Secretary,
The Nuclear Power Plant Co., Ltd.,
Booths Hall,
Knutsford,
Cheshire,

quoting reference TE/CMS/67.

E9958 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

SALES CONTROLLER
(Constructional Steelwork)

for a constructional engineering company in Northern England with a turnover of approximately £2 million.

Sales control has been exercised by the present members of the Board, but there is now an opportunity for a Sales Controller to join the company and assist in its further expansion. He will advise the Board on sales policy, control the sales organisation for direct representatives and agents and negotiate with principal customers.

Commencing salary £2,000 or more for relevant experience, plus other benefits including car, superannuation and assistance with re-housing.

Candidates aged 35–45, should be qualified civil or structural engineers with sales experience in the steel construction industry.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1483, to W. F. Younger.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

CIVIL ENGINEERS

based on London but prepared to go on short visits overseas are required in the

DESIGN DEPARTMENT

for work of an advanced nature on bridges, dams, jetties, &c. These are senior positions calling for good design experience, backed by a degree and a background of construction with contractors, and in the

PROJECT DEPARTMENT

for pre-planning of similar work, calling for good construction experience and some knowledge of design. Minimum qualifications are exemption from Parts A and B of the Institution of Civil Engineers.

These positions give excellent opportunities to gain varied and interesting experience, and should appeal to engineers 28–35 years of age. Please write with salient information to :

The Head of the Design Department,
THE CEMENTATION COMPANY LIMITED
20, Albert Embankment, S.E.11.

E9929 A

W. H. ALLEN, SONS & COMPANY, LTD., BEDFORD

require for their Production Engineering Department

WORK STUDY ENGINEERS

experienced in the application of Work Study to machine or assembly shops.

DRAUGHTSMEN

for the design of Jigs, Tools, Fixtures and Tool Layouts.
These positions will interest men of sound education and practical experience, who can carry out on their own initiative, studies and investigations into problems affecting the small-batch production of Electrical Machinery, Diesel Engines, Steam and Gas Turbines and Centrifugal Pumps.
Please apply in writing, stating age, present salary and full details of education, training and experience to

THE PERSONNEL MANAGER

E9943 A

SITUATIONS VACANT

SENIOR TECHNICAL ENGINEER

A major Industrial Group has a vacancy for a SENIOR TECHNICAL ENGINEER to work in the Technical Department at their Head Office situated in London.

The work is in connection with the investigation and development of new techniques and the efficiency of existing techniques. This is a senior appointment and is an exceptional opportunity for a person with a good honours degree in Mechanical Engineering coupled with a good practical background.

The successful applicant must have a good personality and he must feel that he would be able to accept responsibility in the field of Technical Management later on.

Age range 30–33 years.

Apply, stating full details of age, qualifications and experience to BOX No. E9918, *"The Engineer."*

A

BTR

SALES ENGINEER

required for

FLEXIBLE MOUNTINGS

Excellent salary and prospects of rapid promotion to SALES MANAGER.
Pension : car : expenses.

Preference will be given to candidates with experience and contacts in MARINE and TRACTION engineering, also possessing general knowledge of systems for VIBRATION, SHOCK and NOISE SUPPRESSION.

Send career details to :

Group Personnel Officer (Ref. V.1 3),
BTR INDUSTRIES LTD.,
Herga House, Vincent Square, London, S.W.1

E9949 A

SITUATIONS VACANT

CHIEF ESTIMATOR

Required by Glasgow engineering company to take charge of Department preparing quotations for wide range of engineering equipment, of both mechanical and chemical nature. Quotations will range from relatively small items of equipment to those covering large schemes of process manufacturing plants with total costs up to £2 million. The work will entail charge of staff dealing with enquiries, drawing up specifications, estimating costs and submitting quotations.

Applicants will be required personally to conduct correspondence at high executive level and, where required, to negotiate with clients. They must have had responsible experience in the work described, possess good personality and an administrative flair and be well qualified technically. Technical Sales experience will be an advantage.

The post is a senior one and is covered by the Company's contributory pension and free life assurance scheme.—Applications will be treated in strict confidence.—BOX No. E9914, "The Engineer."

A

CORROSION ENGINEER

An opening is available in London Office of International Oil Company for a B.Sc. METALLURGIST or MECHANICAL ENGINEER to study and solve corrosion problems encountered in the producing, refining and marketing of oil and oil products and to provide technical assistance in the development of materials and protection devices.

Candidates, under forty, must have had a minimum of five years of this experience including practical field inspection and materials work, and be willing to visit overseas locations from time to time.

Apply in writing giving full particulars to BOX No. E9927, "The Engineer."

A

THE STANTON IRONWORKS COMPANY, LIMITED
Near Nottingham

invite applicants for the following staff appointments on its Concrete Plants. The vacancies offer excellent prospects in an expanding organisation. The selected applicants will be engaged on varied and interesting design and research work in connection with both new and existing products which include Prestressed Concrete Pipes, Prestressed Concrete Lighting Columns and Reinforced Concrete Pipes.

DESIGN ENGINEER
Applicants should have had at least three years' design experience, preferably on prestressed and reinforced concrete work. An engineering degree or equivalent will normally be required.

ASSISTANT DESIGN ENGINEER
Applicants should be young engineers with a Higher National Certificate and be capable of undertaking design work under a design engineer.

DRAUGHTSMAN
The minimum qualification is the Ordinary National Certificate and applicants must be prepared to study for the Higher National Certificate in Civil, Structural or Mechanical Engineering.

RESEARCH ASSISTANTS
Qualifications required are the same as those for draughtsmen.

All these posts are permanent and pensionable. Applicants should write, in confidence, to the Staffing Officer, stating age, qualifications and full details of experience.

E9919 A

CHIEF DRAUGHTSMAN DESIGNER

Applications are invited from experienced qualified men for appointment as above.

Minimum Qualifications :

Show proof of sound technical knowledge to A.M.I.M.E. standard.
Have initiative, personality and organising ability.

Minimum Experience :

Some years of workshop or plant experience. Have held a senior position in a drawing office of standing for at least five years. Be conversant with chemical plant.

For the right person there is not an age limit. Please apply with brief details of career, in chronological order, to The Chief Engineer, CIBA Laboratories Limited, Pyewipe, Grimsby.

E9965 A

BAKER PERKINS LIMITED, PETERBOROUGH

require

MACHINE DESIGN ENGINEERS

Baker Perkins, Ltd., together with its home and overseas subsidiary and associated companies, has, for over one hundred years, provided high-class machinery for the food, chemical and allied industries. The increasing demand for complex automatic machinery provides opportunities for experienced, energetic and versatile engineers as machine designers.

Applications for such appointments which are in the bread, biscuit, chocolate, sugar confectionery, chemical and plastics machinery drawing offices of the Company's Headquarters at Peterborough, are invited from men with a minimum of five years' experience in designing complete machines or major sections of automatic plants and who hold at least a Higher National Certificate in Mechanical Engineering. Previous experience of food and chemical processing machinery would be an advantage but is not essential.

It is intended that the successful applicants will be engaged chiefly on design of unit machines and equipment for complete automatic plants and their control. Most of their time will initially be spent on the drawing board, on work which will demand a high degree of initiative and personal design responsibility. Design survey and the subsequent development and proving of machinery will entail some time being spent in customers' factories.

Commencing salary for these appointments will be up to £1250 per annum and, as the Company recognises the importance and value of the design function, there are excellent prospects of advancement. The Company will, if necessary, assist the successful applicants in meeting all reasonable expenses incurred in moving their families to Peterborough and it is also prepared to provide temporary housing accommodation. The Company provides excellent conditions of employment which include pension, life assurance and profit sharing arrangements.

Applications, which would be treated in strict confidence, should give full particulars of qualifications and experience and should be sent to the Personnel Manager, Baker Perkins, Ltd., Westwood Works, Peterborough.

E9952 A

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PATENT NO. 701,249 "RECIPROCATING PUMPS" for sale or licence.—Apply : Chatwin and Company, Chartered Patent Agents, 253, Gray's Inn Road, London, W.C.1. E2294 H

Classified Advts. continued on page 132

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300	Alley MacL.	100	23BX	67½
270	Broomwade	100	E.240	55
240	Broomwade	30	S1	35
215	C.P.T.	100	PB-4-210	50
200	Broomwade	100	D.23	45
150	Broomwade	100	D.22A	35
130	Broomwade	100	D.22	30
120	Tilghman	100	SA12	30
100	Holman	100	T13S	25
100	Reavell	100	DSA6E	25
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80	Reavell	100	DSA6	25
50	Broomwade	100	EH.220	25
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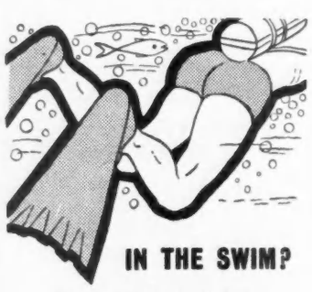

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SALES BY AUCTION

		Main Location	*Auctioneers*
February 24-26	**Machine tools, plant and miscellaneous stores,** including textiles.	M.O.S. Storage Depot, **Byley, Nr. Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
March 3-5	**Machine tools and miscellaneous stores,** including	M.O.S. Storage Depot, **Royal Arsenal, Woolwich, S.E.18**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
	Horizontal boring machines; S.S. and S.C. lathes; vertical milling machines; vertical drilling machines; grinders; hacksawing machines; high-speed milling cutters; pneumatic hammer; fork lift and industrial trucks; generating and charging sets; compressors; concrete mixers; Willeys jeep petrol engines; wheelbarrows; extending ladders; jacks; light steel tubs; radio and electric stores and equipment; portable batteries; engineers' hand tools; prismatic compasses; theodolites; blankets; boxes, etc.		
March 9-10	**Miscellaneous stores,** including large quantity of vehicle tyres, etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
March 12	**Office, etc., furniture and racking.**	Hawker Aircraft Factory, **South Shore, Blackpool.**	**LESLIE A. BUTSON** (Dept. L), 16, Birley Street, Blackpool. (Tel.: 21073.)
March 16-18	**Machine tools, plant and miscellaneous stores,** etc.	M.O.S. Storage Depot, **Harrogate Road, Yeadon, Leeds.**	**DACRE, SON & HARTLEY** (Dept. L), Station Road, Otley, Yorks. (Tel.: 3321.)
March 20	**Miscellaneous stores,** including clothing, etc.	Command Ordnance Depot, **Coypool, Marsh Mills, Plymouth.** (Sale at Kinterbury House.)	**WOOLLAND, SON & MANICO** (Dept. L), Kinterbury House, St. Andrews Cross, Plymouth. (Tel.: 65356.)

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Tenders must be submitted by 16th March, 1959.

APPLICATIONS (*a*) for catalogues for the auction sales should be made *only* to the Auctioneers shown above (price of catalogues 1s., P.O. only).
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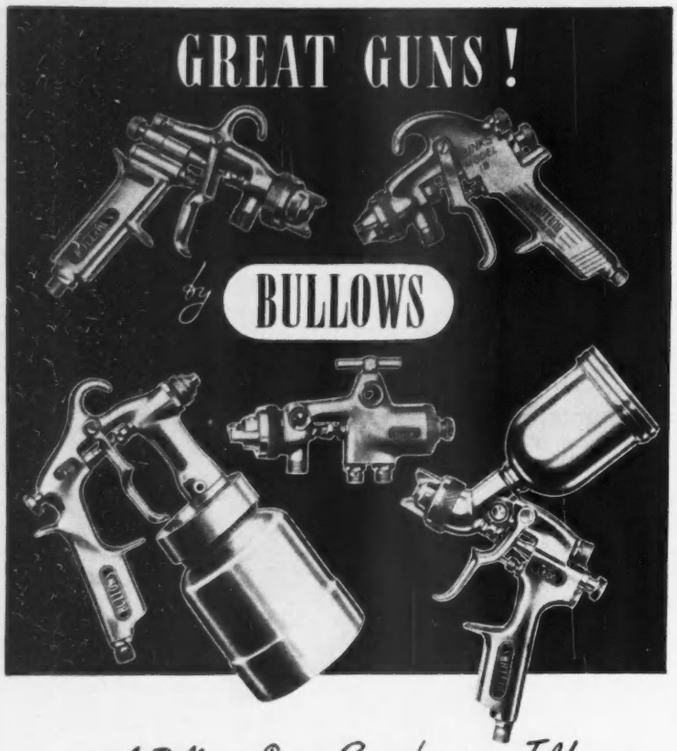

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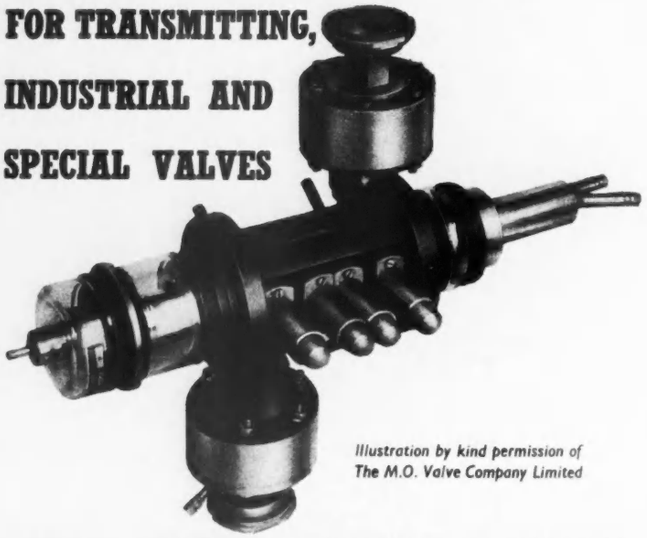

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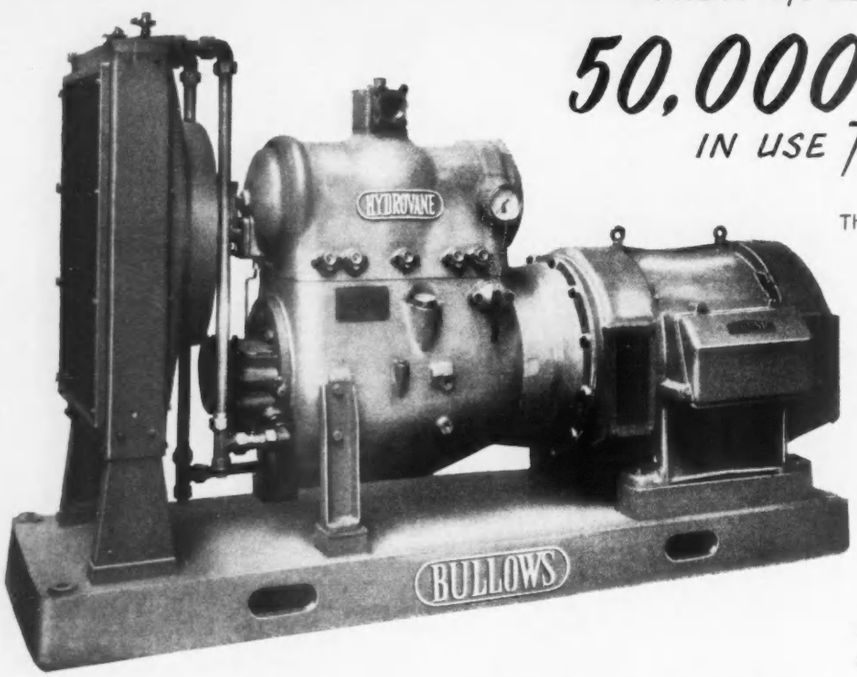

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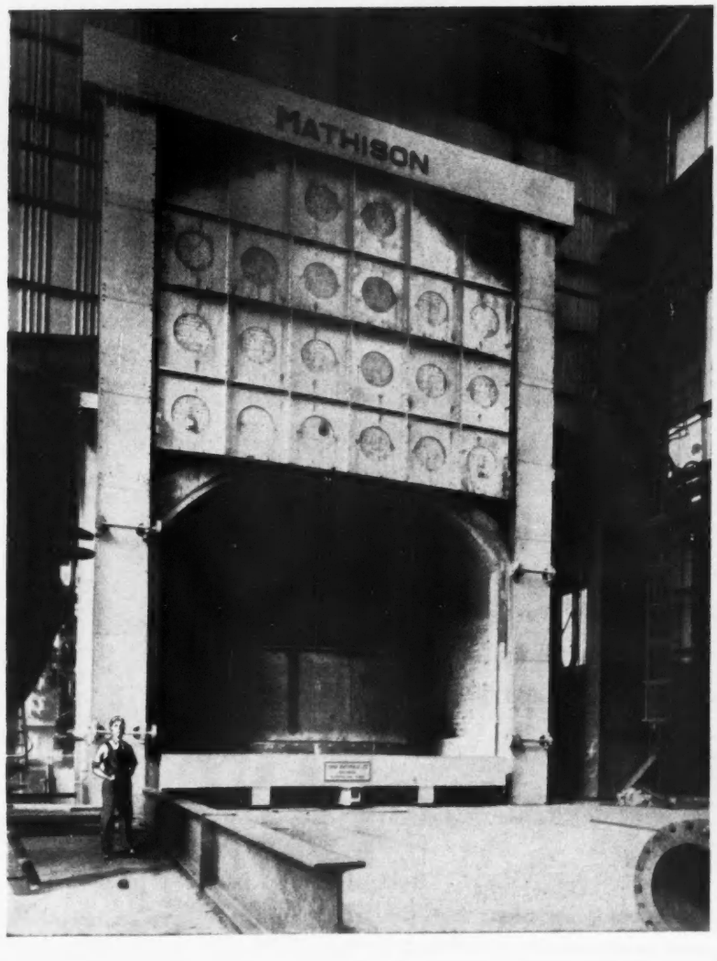

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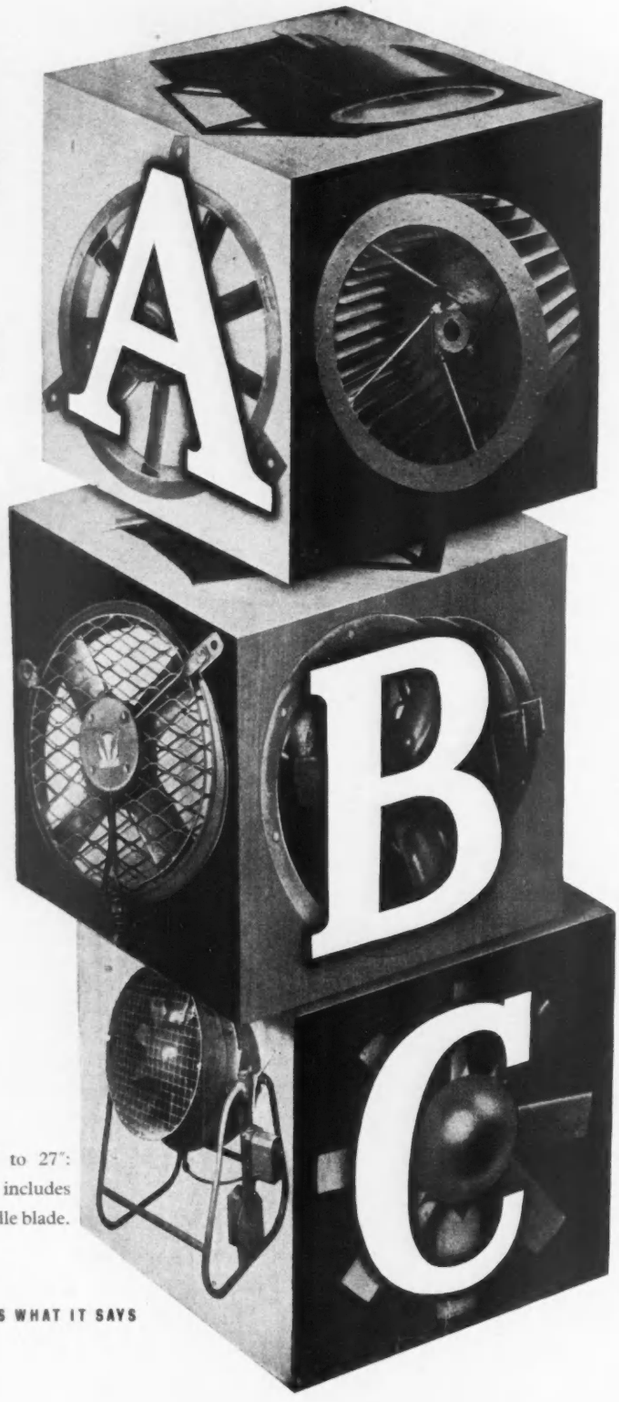

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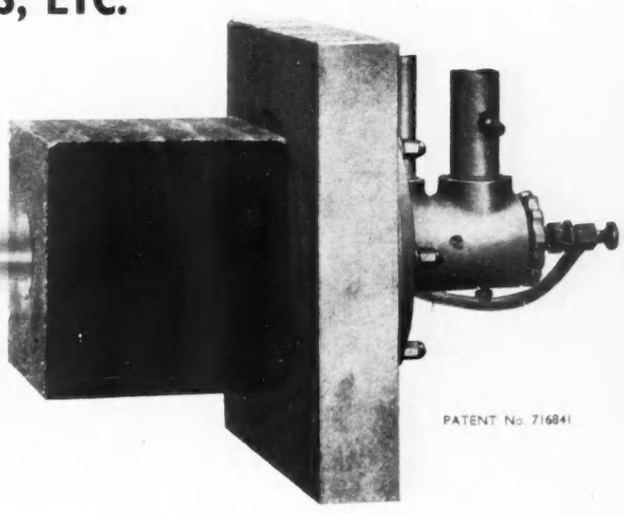

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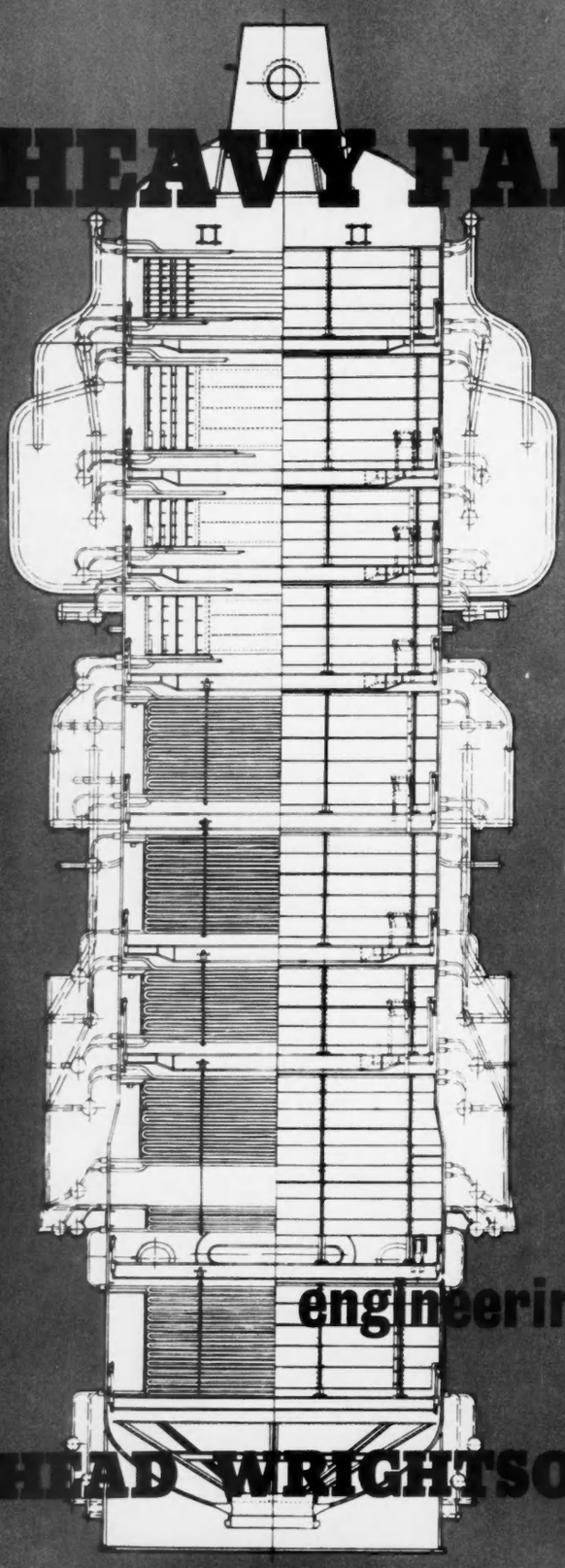

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